401B
DuMont

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TYPE
401B
401BR
Operating and Maintenance Manual
OSCILLOSOPE

Serial No. ____________________

DU MONT

ELECTRONIC TUBES • ELECTRONIC INSTRUMENTATION • INDUSTRIAL TELEVISION • MILITARY ELECTRONICS • AUTOMOTIVE TEST EQUIPMENT • TWO WAY RADIO

ALLEN B. DU MONT LABORATORIES, INC., CLIFTON, NEW JERSEY, U. S. A.

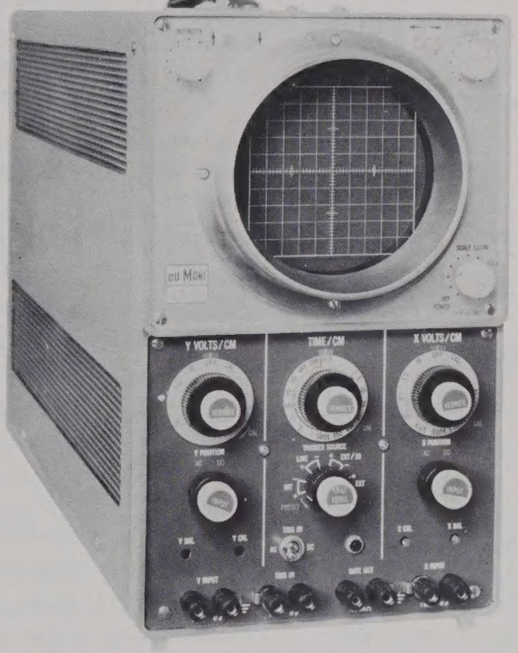


Figure 1-1a. Du Mont Type 401-B Oscilloscope

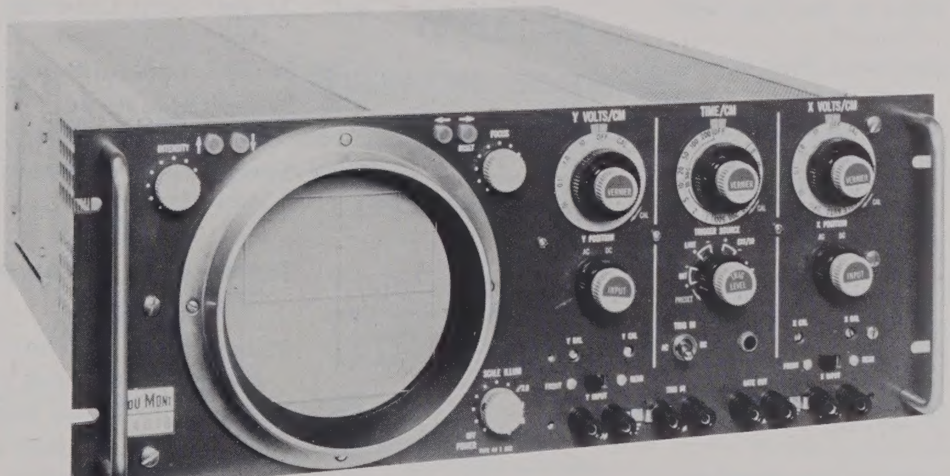


Figure 1-1b. Du Mont Type 401-BR Oscilloscope

TABLE OF CONTENTS

Section *Title* *Page*

1. TECHNICAL SUMMARY

1-1 Introduction 1-1
1-2 Purpose 1-1
1-3 Features 1-1
1-4 List of Recommended Accessories 1-2
1-5 Technical Summary 1-2

2. OPERATING INSTRUCTIONS

2-1 General 2-0
2-2 Thermal Cutout 2-0
2-3 Precaution Against Screen Burning 2-0
2-4 Illuminated Scale 2-1
2-5 Beam Position Indicators 2-1
2-6 First Time Operation 2-1
2-7 Effect of the AC/DC Switches 2-3
2-8 Effect of the Front-Panel Bal Controls 2-3
2-9 Effect of the Y Volts/Cm Switch 2-3
2-10 Effect of the Trigger Source Switch 2-3
2-11 Effect of the Trig Level Control 2-4
2-12 Operating Hints for the Vertical Deflection Channel 2-9
2-13 Use of Probes 2-10
2-14 Operating Hints for the Sweep Channel 2-11
2-15 Rear Panel Facilities 2-13
2-16 Deflection Plate Connections 2-13
2-17 Intensity (Z Axis) Modulation 2-16
2-18 Voltage Measurements 2-16
2-19 Time Measurements 2-18
2-20 Rise-Time Measurements 2-19
2-21 Phase Shift Measurements 2-19

3. CIRCUIT DESCRIPTION

3-1 General 3-1
3-2 Vertical Deflection System 3-1
3-3 Horizontal Deflection Amplifier 3-2
3-4 Trigger Circuit 3-2
3-5 Sweep Circuit 3-5
3-6 Low-Voltage Power Supply 3-6
3-7 High-Voltage Power Supply 3-6

Section *Title* *Page*

4. MAINTENANCE

4-1 Introduction 4-1
4-2 Preventive Maintenance 4-1
4-3 Gaining Access to the Chassis 4-2
4-4 Cathode-Ray Tube Replacement 4-2
4-5 Illuminated Scale Lamp Replacement 4-2
4-6 Servicing Hints 4-2
4-7 Replacement Parts 4-3
4-8 Locations of Tubes, Service Adjustments, and Test Points 4-3
4-9 Service Adjustments 4-4
4-10 Low Voltage Power Supply 4-4
4-11 Deflection Plate Level Adjust 4-5
4-12 CRT Potential Adjustments 4-5
4-13 DC Balance Adjustments 4-6
4-14 Calibrator and Amplifier Adjustments 4-6
4-15 Phase Shift Adjustment 4-7
4-16 Attenuator Adjustments 4-7
4-17 Trigger Level Centering Adjustment 4-8
4-18 Sweep Length Adjustment 4-8
4-19 Sweep Calibration Adjustments 4-8
4-20 Sweep Expansion Point Adjustments 4-8

5. PERFORMANCE ASSURANCE TEST

5-1 Maintenance Check to Assure Performance 5-1
5-2 Checking the Power Supply 5-1
5-3 Checking the Vertical and Horizontal Deflection Amplifiers 5-2
5-4 Checking the Sweep 5-2
5-5 Checking Frequency Response of X and Y Amplifiers 5-3

6. ELECTRICAL PARTS LIST AND SCHEMATICS

- Provision for connection of external capacitance provided at rear of instrument for extension of sweep time
- Driven, automatic, or single (armed) sweep operation with automatic forward trace brightening
- Examination on the screen of any portion of signal expanded up to at least five times full scale without distortion
- Provision for Z-Axis (intensity) modulation
- Provisions for direct access to the deflection plates of the cathode-ray tube.
- Regulated high and low-voltage supplies
- Tube and component selection not required

1-4. LIST OF RECOMMENDED ACCESSORIES

TYPE OR PART NUMBER	DESCRIPTION
	FILTERS
4800 4511	Color filter, green for P1 and P2 screen
4800 4512	Color filter, blue for P11 or P7 screen
4800 4513	Color filter, amber for P7 screen
	PROBE AND KIT
4290	10:1 Attenuator Probe
4001	Sweep Rearming Kit
	TABLES
2601-A	Movable table, non-adjustable shelf
or	
2602	Movable table, adjustable shelf
	TERMINAL ADAPTER
2592-B	Terminal Adapter, un-terminated, for use with BNC Type connector
	VIEWING ACCESSORY
276-C	Viewing hood

1-5. TECHNICAL SUMMARY

The electrical and physical characteristics of the Types 401-B and 401-BR are listed in Table 1-1 which follows.

TABLE 1-1

TECHNICAL SUMMARY

DU MONT TYPES 401-B AND 401-BR OSCILLOSCOPES

CATHODE-RAY TUBE DATA	
CRT	
Type	K1931-P1 tight tolerance CRT is normally supplied; P7 phosphor for long persistence low frequency or transient observation; P11 for photographic use; and P2 phosphor for combination visual and photographic use are also available; aluminazation optional
Over-all Accelerating Potential	5000 volts
Bezel	Light-proof bezel provides firm mount for an oscilloscope camera and permits ready interchange of filters and scales
CRT Scale	Engraved edge-lit scale having 10 cm by 10 cm graduations and appropriate color filter over face of tube. Scale Illumination control varies illumination level from zero to intensity adequate for photographic recording. Non-parallax scale optional
CRT DIRECT INPUT (Terminals are available at the rear of the instrument)	
X Axis	Deflection Factor: from 10 volts/cm to 14 volts/cm
Y Axis	Deflection Factor: from 10 volts/cm to 14 volts/cm

SECTION I

TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of Operating and Maintenance instructions covers information on both the Type 401-B (bench model) and Type 401-BR (rack mounted) Oscilloscopes. Electrically, the two types are identical; mechanically, they differ in exterior appearance. These differences are clearly indicated in the text. Otherwise, references throughout the manual to the Type 401-B pertain also to the Type 401-BR.

1-2. PURPOSE

The Du Mont Type 401-B Oscilloscope is a measuring instrument designed to be used for almost any general application. The high gain of this instrument assures that it can be used directly with many types of transducers, while dc amplification provides that the lowest frequency portions of signals will be faithfully reproduced.

1-3. FEATURES

- K1931-P tight tolerance cathode-ray tube with 5000 volts over-all accelerating potential; screen aluminazation optional
- Provisions for balanced or single-ended vertical and horizontal input signals
- Identical frequency response and gain of both X and Y amplifiers extending from dc to 3 db down at 450 Kc at a sensitivity of 10 millivolts/cm
- Calibration voltage is provided for each amplifier
- Calibrated linear sweep rates from 200 milliseconds/cm to 5 microseconds/cm in fifteen steps of 2, 5, 10, and 20 sequence
- Uncalibrated linear sweep, continuously variable in rate from 1 second/cm to 1 microsecond/cm. Longest sweep time is 10 seconds full scale

TABLE 1-1 (Continued)

TRIG INPUT COUPLING—Continued	
DC	Direct coupled to 500 Kc to: (1) preserve very low frequencies, (2) maintain the initial starting point of the trace on the scale for a given trigger level setting; and (3) avoid effects of random repetition rate trigger sginals
SLOPE LEVELING	
Polarity	Selection of positive or negative slopes on Internal, Line, or External triggering is available
Trigger Level	A range of ± 12 volts for direct External Trigger Input or 1½ times full scale on internal triggering. Preset position provides fixed optimized sensitivity. On External/10 Trigger Source, the leveling range is extended to ± 120 volts.
TRIGGER SENSITIVITIES	
Internal	Signals will synchronize from ½ centimeter of vertical signal on driven and single sweep position. Less than 2 millimeters are required in the auto triggering position. A choice of trigger polarity (slope) is available
Line	Line frequency synchronization can be selected in either polarity (slope) and the triggering point may be shifted with the trigger level control
External	0.25 volt peak-to-peak (250 millivolts peak-to-peak) from dc to approximately 300 Kc will synchronize the sweep The 10:1 external trigger attenuator will permit trigger signals greater than 200 volts peak-to-peak (± 100 volts) to be useful. Trigger leveling, polarity selection, and ac or dc coupling are included. 0.5 volt peak-to-peak will trigger the sweep from dc to over 500 Kc in Driven and Single Sweep positions. Approximately 0.4 volt peak-to-peak is required in Auto Triggering operation
AUTOMATIC TRIGGERING	
Features	Auto triggering is available in conjunction with preset or vernier trigger leveling, on internal, external, and line trigger sources. Auto triggering simplifies synchronization and provides a continuous base line at a frequency of approximately 50 cycles
	SWEEP CIRCUIT
TIME BASE	
Calibrated	From 200 milliseconds/cm to 5 microseconds/cm in 15 steps. Step sequence in 1, 2, 5, and 10. An "off" position is included
Uncalibrated	Continuously variable, uncalibrated between ranges and extends the 200 milliseconds/cm range to 1 second/cm (10 seconds full scale)
Accuracy	Normally within 3%; always within 5% (full scale)
Sweep Expansion	5 times expansion. Extends fastest sweep rate to 1 microsecond/cm within ± 10%
Expanded Sweep Positioning	Sufficient to position any full scale portion of the expanded trace (50 cm) on the screen
Extension of Lower Sweep Rates	External Sweep Capacitor Terminals are provided on the rear panel for slower sweeps. See Section 2, Operation, for further details
Single Sweep	The single sweep mode permits but one driven sweep of the time base to appear on the screen until the sweep is reset. A reset adapter kit, the Du Mont Type 4001, is available for use with external resetting contact closures (as may be found on mechanical devices, Du Mont oscilloscope camera shutters, etc.)
Electronic Shutter	Controlled exposure brightening for multiple trace X-Y displays through use of driven sweep. This feature may be switched out by setting the sweep to the "off" position

TABLE 1-1 (Continued)

CRT DIRECT INPUT—Continued	
Z Axis	Positive pulse to cathode of CRT blanks trace. 15 volts needed into an impedance of approximately 1000 ohms coupled via 0.01 μf capacitor. Time constant is approximately 10 milliseconds

VERTICAL-DEFLECTION SYSTEM

BANDWIDTH	
Direct Coupled	DC to 500 kilocycles; down 3 db ± 1 db at 500 kilocycles 6 centimeters of undistorted deflection at 1 megacycle
Capacitively Coupled	From 2 cycles to 500 kilocycles
Rise Time	0.8 microseconds with less than 2% overshoot
SENSITIVITY	
Input Attenuation	Provided by a frequency compensated attenuator with steps from 10 millivolts/cm to 10 volts/cm, accurate to within 2% when set on any one step. An OFF position is included for dc balancing
Calibrated Operation	From 10 millivolts/cm to 10 volts/cm in four decade steps when VERNIER control is preset to CAL
Uncalibrated Operation	Continuously variable from 10 millivolts/cm to 100 volts/cm. VERNIER control permits 10 to 1 continuous sensitivity adjustments between the decade attenuator steps and extends the 10 volts/cm range to 100 volts/cm
Positioning Range	5 times full screen
INPUT DATA	
Input Connectors	Combination binding posts spaced on ¾-inch centers to accommodate the Du Mont Type 2592-B shielded terminal adapter. Two binding post connectors are provided for balanced vertical input and a ground binding post and connector strap are provided for single-ended amplifier operation
Input Impedance	
Single-ended	1 megohm, constant within ± 3% at all attenuator settings; nominally 47 pf ($\mu\mu$f), constant within ± 5% from range to range
Balanced	2 megohms shunted by less than 40 pf ($\mu\mu$f)
Input Coupling	
Single-ended	Direct or through capacitor of 600-volt rating to amplifier
Balanced	10 millivolts/cm range (DC only); adjustable to 100 millivolts/cm (push-pull)
COMMON MODE	
Rejection Ratio	Nominally 120:1, always better than 100:1 (40 db)
Maximum Signal	Common mode signal must not exceed ± 3 volts dc plus peak ac
PHASE SHIFT	
Features	Vertical and horizontal amplifiers are identical. At maximum gain, the phase shift between the orthogonal systems is adjustable to ± 1 degree at any point from dc to 300 Kc. When adjusted to 0° at 200 Kc, the phase shift differential is ± 2° from dc to 250 Kc

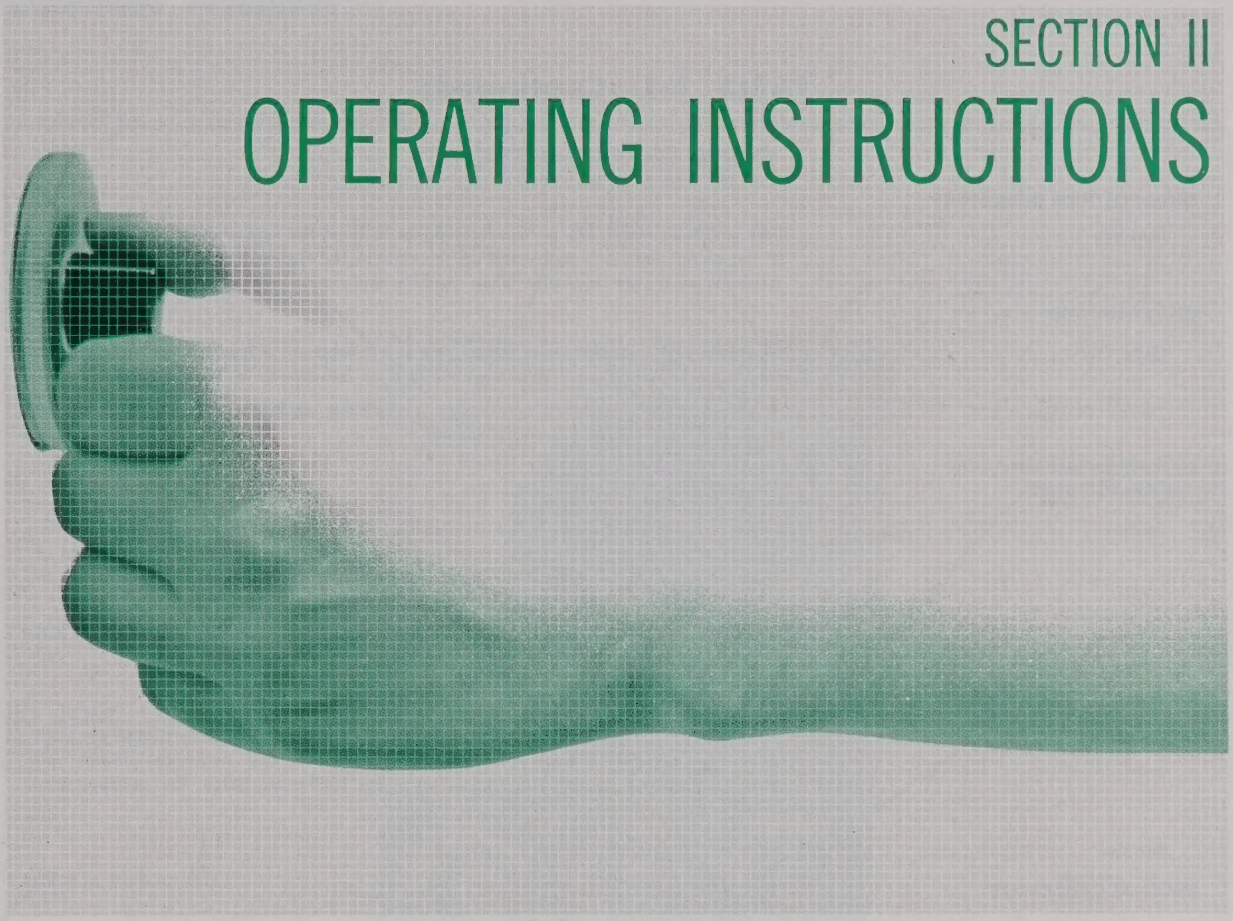
HORIZONTAL-DEFLECTION AMPLIFIER

(Same characteristics as the Vertical Deflection Amplifier)

SYNCHRONIZATION

TRIG INPUT COUPLING	
AC	80 cycles to 500 Kc minimum

SECTION II
OPERATING INSTRUCTIONS



2-1. GENERAL

The Du Mont Types 401-B and 401-BR Oscilloscopes are shipped with all tubes in place and ready to operate. Since these instruments are portable, no special installation procedure is required. The rack-mounted model has a front-panel 19 inches wide by 7 inches high for mounting the instrument in a standard relay rack or cabinet. Mounting holes are provided on each side of the 401-BR for the attachment of slides.

Normally the Type 401-B or 401-BR may be placed where most convenient for viewing while at the same time maintaining short signal leads. Although shielding has been provided, operation in very strong magnetic fields may cause spurious deflections and should be avoided. Re-orientation or additional shielding of the instrument may be necessary to minimize the effects of such fields.

The instrument is intended for operation from a 48 through 1000 cycles, single-phase, 115/230-volt power source and will operate satisfactorily with line voltage variations of ± 10%.

Numerous accessory components are available from the Allen B. Du Mont Laboratories, Inc., to extend the usefulness of these oscilloscopes. See Section 1 for further details.

2-2. THERMAL CUTOUT (Type 401-BR only)

A thermal cutout switch is connected in series with one side of the power line in the rack-mounted version of the Type 401-B. When the interior temperature of the instrument exceeds the safety limit, the thermal cutout switch will trip, removing power from the unit. It will reset itself when the interior temperature drops to a safe value. Possible causes of overheating are restriction of air circulation or high ambient temperature.

2-3. PRECAUTION AGAINST SCREEN BURNING

A sharply focused spot of high intensity and small area should not be permitted to remain stationary on the screen for any length of time.

TABLE 1-1 (Continued)

OTHER CHARACTERISTICS

BEAM POSITION INDICATORS	
Features	Four indicator lamps are on the front panel to alert the operator as to the direction of the beam when it is positioned off the screen. The right-hand indicating lamp also functions as a reset indicator when used in conjunction with the single sweep mode
UTILITY SIGNALS	
Gate Out	Negative gate coincident with sweep time is available on a front panel binding post. Amplitude is more than 5 volts negative into an impedance of 10,000 ohms
10-Volt DC Out	A 10-volt, high impedance dc voltage is available at the rear panel to facilitate triggering from external contact closures
REAR TERMINALS ON RACK-MOUNTED UNIT	
Features	Front panel input terminals are duplicated at the rear of the rack-mounted unit. Front/rear switching is provided on the X and Y amplifier inputs to allow choice of either front or rear connections. Input capacities are higher than the bench unit at the external trigger input and the rear terminals of the X and Y inputs Universal binding post type connectors are used at the rear of the rack-mounted units
AMBIENT TEMPERATURES	
Operating	From 0°C to + 40°C. The 401-BR incorporates a thermal cutout to protect the unit when rack cooling is insufficient. Adequate ventilation and clearance around unit must be provided in rack installation to assure intake air below the specified ambient temperature
Storage	From — 20°C to + 85°C
INTERNAL CALIBRATOR	
Features	Line frequency trapezoidal wave signal injected into the amplifier behind the attenuator to standardize gain. Accuracy nominally 1%, always within 2%

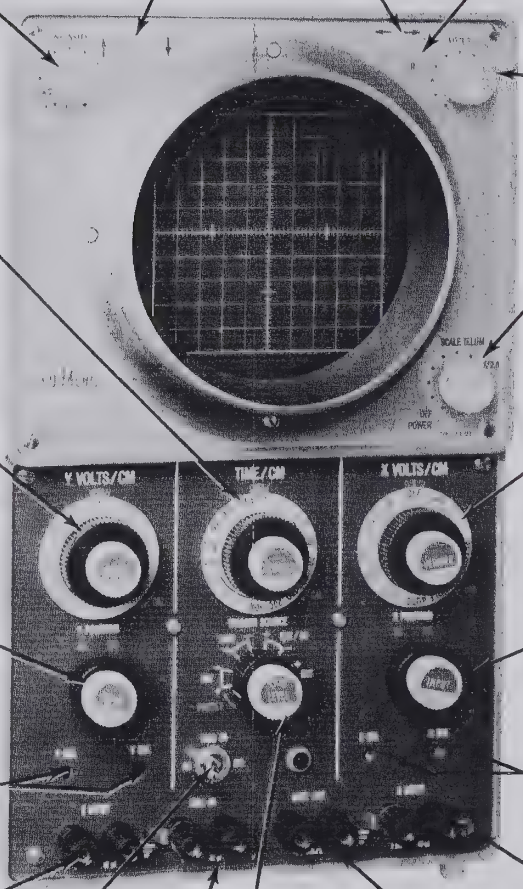
POWER SUPPLY

POWER REQUIREMENTS	
Line Voltage	From 103.5 to 127.5 volts or from 207 to 255 volts at 60-cycle line
Line Frequency	Operation from 48 through 1000 cycles
Power	230 watts average; 250-volt amperes at 115-volt, 60-cycle line
Fuses	115-volt operation, 3 amperes 230-volt operation, 1.5 amperes
DC Power Supplies	Electronically regulated

PHYSICAL CHARACTERISTICS

BENCH MODEL		
Height	15½ inches	(39.4 cm)
Width	8¾ inches	(22.3 cm)
Depth	23¼ inches	(59.2 cm)
Weight	45 pounds	(20.4 kg)
RACK-MOUNTED MODEL		
Height	7 inches	(17.8 cm)
Width	19 inches	(48.4 cm)
Depth	23⅛ inches 22 inches behind panel	(58.7 cm) (55.0 cm)
Weight	45 pounds	(20.4 kg)

section 2
operating instructions



BEAM POSITION INDICATORS

Indicates direction in which beam is off screen

INTENSITY: Varies trace brightness

R — Indicates RESET: Right indicator light when lit indicates sweep requires resetting. Used with single sweep mode only.

TIME/CM: Selects calibrated sweep rates as indicated on knob skirt

VERNIER: Provides a 5:1 variation of sweep rate within limits of Time/Cm setting

FOCUS: Adjusts trace sharpness

POWER & SCALE: Turns power on or off. Attached control varies scale illumination

Y VOLTS/CM: Calibrated attenuator with steps from 0.01 to 10 volts/cm

VERNIER: Provides a 10:1 variable adjustment permitting max gain and overlap of the Volts/Cm setting

X VOLTS/CM: Calibrated attenuator with steps from 0.01 to 10 volts/cm including positions DRIV, AUTO, and SINGLE sweep

VERNIER: Provides a 10:1 variable adjustment permitting max gain and overlap of the X Volts/Cm setting

Y POSITION: Positions trace vertically

INPUT: Inserts blocking capacitor in the Y Input

X POSITION: Positions trace horizontally

INPUT: Inserts blocking capacitor in X Input

Y CAL: Calibration adjustment of Y Amplifier gain

Y BAL: When adjusted prevents vertical movement of the trace when Vernier is varied

X CAL: Calibration adjustment of X Amplifier gain

X BAL: When adjusted prevents horizontal movement of the trace when Vernier is varied

Y INPUT: Connection for external signal to the vertical amplifier

X INPUT: Connection for external signal to the X Amplifier

TRIG IN (AC-DC): Inserts blocking capacitor when using external signals

GATE OUT: Provides a negative gate out for operation of auxiliary equipment

TRIG LEVEL: Determines voltage level horizontal trace will start

TRIG IN: Connection for external sync signals through EXT positions of Trigger Source switch

TRIGGER SOURCE: Eight position switch selects the source and slope for triggering

Figure 2-1. Function of Controls and Connectors

Under such conditions, the entire beam energy is concentrated over a small area, thus subjecting the screen material to burning and discoloration. This condition is most likely to exist when using the unit for X-Y plotting with the INTENSITY turned up, and no signal inputs. The INTENSITY LIMIT control R3119 located on the rear panel, may be adjusted to limit beam current to a safe value.

2-4. ILLUMINATED SCALE

The adjustable scale lighting control labeled SCALE ILLUM may be adjusted to suit the lighting conditions of the room or the f/number on the oscilloscope camera. The color filter supplied is tinted to provide the maximum trace contrast in the presence of room light. The colored filter should be mounted next to the cathode-ray tube so it does not block light from the calibrated scale, and should be removed when photographing the display.

The scale is accurately scribed in centimeters. These scale markings and the calibrated fixed attenuator markings and sweep rates, can be used to convert deflection in centimeters into volts and seconds. Vertical and horizontal sensitivities are accurately calibrated in volts per centimeter and TIME/CM switch settings are accurately calibrated in seconds per centimeter, which when multiplied by the number of centimeters of deflection give the voltages and seconds.

2-5. BEAM POSITION INDICATORS

Four indicator lamps located above the bezel indicate the position of the beam on the CRT screen. The two beam indicators on the left of the bezel function with the vertical movement of the beam, and the two on the right function with the horizontal. When one of the indicator lamps light, it indicates the direction in which the display is positioned off screen thus indicating the direction in which to turn the POSITION control to return the display to the screen. The indicators also enable the display to be positioned on screen when the INTENSITY level is set so low that the trace is invisible.

The right indicator lamp with RESET lettered beneath it is used during single sweep operation. When lit, it indicates the sweep requires rearming. Refer to Section 2-14c for further details.

2-6. FIRST TIME OPERATION

a. Instructions

To place the instrument in operation, plug the power cord into the proper grounded power source and turn INTENSITY control counterclockwise. Rotate the SCALE ILLUM control clockwise to apply power. Allow approximately 10 minutes for the instrument to warm up. In the instructions which follow, the words in capital letters within the text, indicate front-panel controls, connectors or settings. A brief description of the front-panel controls and connectors is given in Figure 2-1.

b. Initial Control Settings

The operator is advised to follow the specific instructions and sequence of operation as outlined in this Section. Set the various front-panel controls as indicated in Table 2-1. A pattern as indicated in Figure 2-2 should appear on the screen. At this time the operator may familiarize himself with the various controls and their effect on the built-in calibrator signal.

TABLE 2-1
INITIAL CONTROL SETTING

CONTROL	SETTING
Y VOLTS/CM	CAL
TIME/CM	2 MS/CM
X VOLTS/CM	AUTOmatic Sweep
VERNIERS (all three)	CAL
X & Y POSITION	Centered
X & Y INPUT	AC
TRIGGER SOURCE	+ INT
TRIG LEVEL	PRESET
TRIG IN	AC
INTENSITY	Suitable brightness
FOCUS	Sharp trace

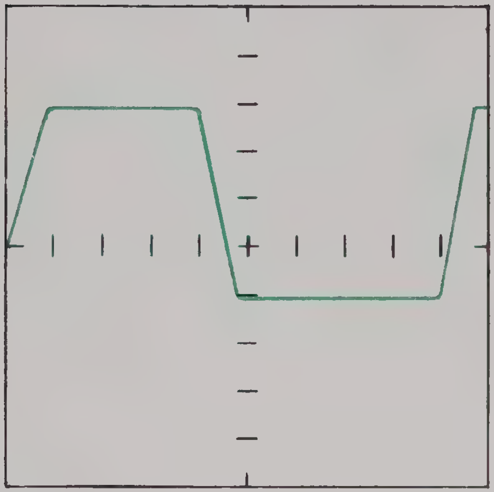


Figure 2-3. Trigger Source Switch Set to +INT

a. Positive Polarity (+Int)

Set front-panel controls in accordance with Table 2-1, except place the X VOLTS/CM switch in DRIVen and adjust Y VERNIER control for 4 centimeters of vertical deflection. Observe the left side or beginning of the trace. Notice that it starts during the rising portion of the waveform indicating that the sweep is triggered at a time when the slope of the waveform is positive. See Figure 2-3.

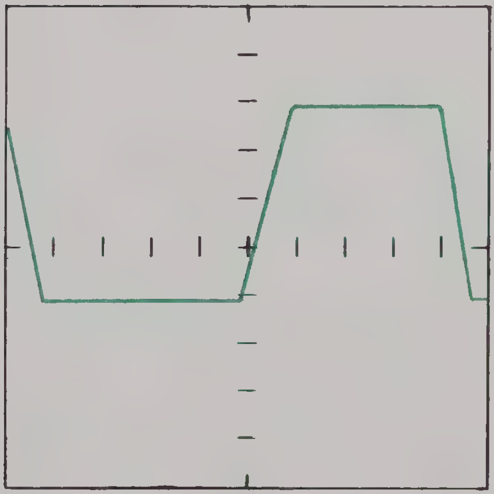


Figure 2-4. Trigger Source Switch Set to —INT

b. Negative Polarity (—Int)

Reset TRIGGER SOURCE switch to — INT and notice that the waveform appears to have turned upside down. In the — INT position, the trace begins on the falling portion of the waveform indicating that the sweep is triggered at a time when the slope of the waveform is negative. See Figure 2-4.

2-11. EFFECT OF THE TRIG LEVEL CONTROL

The TRIG LEVEL control permits selection of specific voltage the triggering signal must exceed before the sweep fires. A preset position on the TRIG LEVEL control permits ready availability of a stable, resettable, sensitive trigger level which will perform 90% of all triggering.

a. AC Triggering Mode

The TRIG LEVEL control determines the point on the waveform where the display starts.

1. Set the TRIGGER SOURCE switch to + INT, and notice that the display starts on the rising portion of the waveform where the slope is positive.

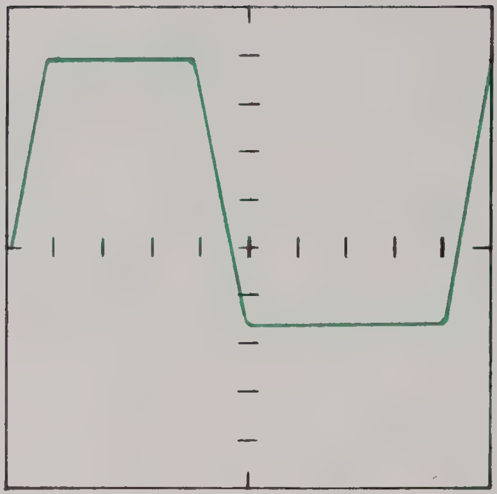


Figure 2-2. Calibrator Waveform Display

2-7. EFFECT OF THE AC/DC SWITCHES

Three separate AC/DC switches are employed in the Type 401-B Oscilloscope. Each switch permits the choice of retaining the dc level of the input signal or blocking the dc component of the input signal by inserting a blocking capacitor, one each in series with the input of the vertical and horizontal deflection amplifiers, and one in the input of the Trig Amplifier and Level Selector V210.

Separate INPUT switches (S111 and S121) select the desired AC/DC position for signals applied to the vertical and horizontal amplifiers. The TRIG IN switch (S211) selects the desired AC/DC position for application of all signals to the trigger circuit.

When either of these switches are set in the AC position, the effect of the dc component is excluded from the display. When set in the DC position, the ac signal and dc level of the waveform can be noted. The dc component will cause the entire display to rise or fall on the screen.

Reset switches to the AC position.

2-8. EFFECT OF THE FRONT-PANEL BAL CONTROLS

a. Y Bal

Set the Y VOLTS/CM switch to OFF and turn the Y VERNIER control counterclockwise. The reference trace on the screen should not drift vertically while rotating the VERNIER control throughout its range.

If trace shifts vertically, proceed as follows:

1. Turn VERNIER control to minimum.
2. Position trace to center of screen.
3. Turn VERNIER control to maximum.
4. Adjust the Y BAL control to bring trace back to center of screen.
5. Repeat this procedure until no depositioning of the trace is noted when the VERNIER control is rotated throughout its range.

Reset the Y VOLTS/CM switch and the VERNIER control to Cal.

b. X Bal

Set the X VOLTS/CM switch to OFF and turn the X VERNIER control counterclockwise. The reference trace on the screen should not drift horizontally while rotating the VERNIER control throughout its range.

If trace shifts horizontally, repeat steps 1 through 5 in Paragraph 2-8a above, using the X BAL and X VERNIER controls.

Reset the X VOLTS/CM switch and VERNIER control to CAL.

2-9. EFFECT OF THE Y VOLTS/CM SWITCH

With a signal of approximately 0.5 volt peak-to-peak applied to Y INPUT, turn the Y VOLTS/CM control to positions both to the right and left of the 0.1 setting. Notice that when the control is set to the higher number setting, the amplitude of the waveform is reduced and vice versa.

Reset the Y VOLTS/CM switch to 0.1 position, and turn its VERNIER control counterclockwise. Notice that counterclockwise movement of the VERNIER control decreases the amplitude of the signal being displayed and clockwise rotation increases the amplitude. When the VERNIER control is in the fully clockwise or CAL position, the signal is restored to its original calibration. Thus, it is seen when a given voltage is applied to Y INPUT, the Y VOLTS/CM and VERNIER controls are used for adjusting the amplitude of the resulting vertical deflection. Remove input signal and reset Y VOLTS/CM switch to CAL.

2-10. EFFECT OF THE TRIGGER SOURCE SWITCH

The TRIGGER SOURCE switch permits selection of the source and polarity of the sweep triggering signal.

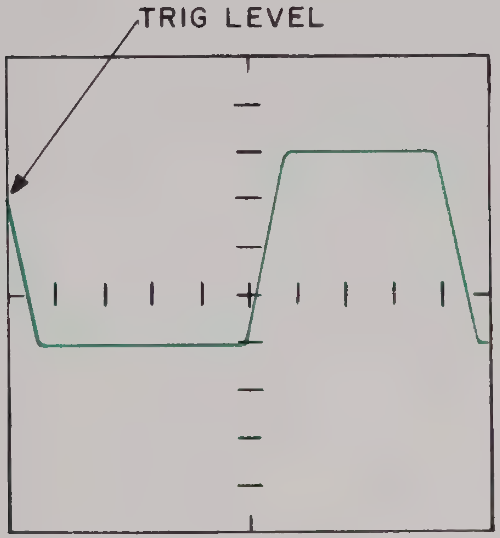


Figure 2-7. Effect of Trig Level Control when Slope is Negative

4. Set the TRIGGER SOURCE switch to — INT, and notice that the waveform appears to have turned upside down. The display is now beginning during the falling part of the waveform where the slope is negative.
5. Rotate the TRIG LEVEL control slowly in the clockwise direction and observe that the display starts on the higher portion of the waveform. See Figure 2-7.

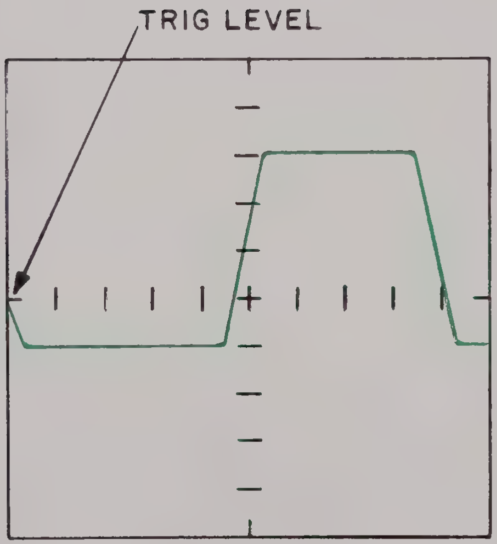


Figure 2-8. Effect of Trig Level Control when Slope is Negative

6. Rotate the TRIG LEVEL control slowly in the counterclockwise direction and observe that the display starts on the lower portion of the waveform. See Figure 2-8.

2. Rotate the TRIG LEVEL control slowly in the clockwise direction and observe that as the control switches from the PRESET position, the trace disappears. As the control is rotated more in the clockwise direction, the display reappears and the start of the display shifts to fire on the higher portion of the waveform. See Figure 2-5.

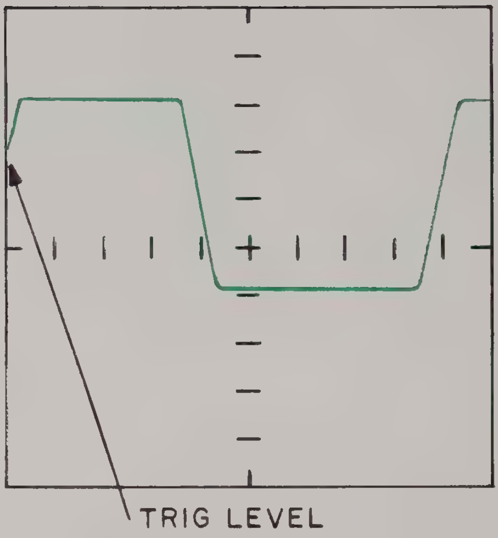


Figure 2-5. Effect of Trig Level Control when Slope is Positive

3. Rotate the TRIG LEVEL control slowly in the counterclockwise direction and observe that the display starts on the lower part of the waveform. When in the PRESET position, the original calibrated waveform is restored. See Figure 2-6.

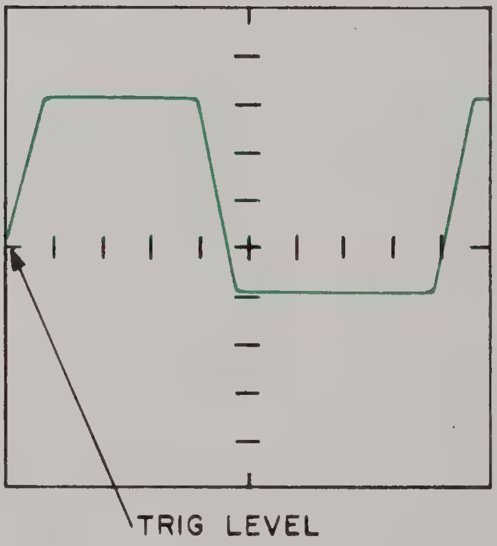


Figure 2-6. Effect of Trig Level Control when Slope is Positive

b. DC Triggering Mode

1. Set TRIG IN switch to DC. You are now triggering in the DC mode. Slowly turn the TRIG LEVEL control throughout its range observing the left side of trace. Note that the results are similar to those obtained when using AC mode. Set the TRIGGER SOURCE switch to — INT and again operate the TRIG LEVEL control. Note again that the results are similar to those obtained when using the AC mode.
2. Reset TRIGGER SOURCE switch to + INT, TRIG LEVEL control to PRESET, and Y VERNIER control to CAL.
3. Rotate Y POSITION control throughout its range observing the left side of the display as it is positioned up and down. Notice that for a given setting of the TRIG LEVEL control, the trace starts at the same point on the *Scale* regardless of the setting of the Y POSITION control. If you position the display above or below the setting, the trace will disappear. See Figures 2-11, 2-12, and 2-13.

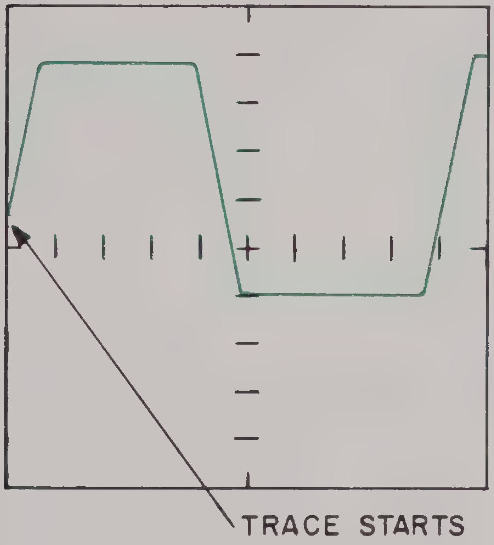


Figure 2-11. Vertical Positioning in the DC Mode

Display positioned upward

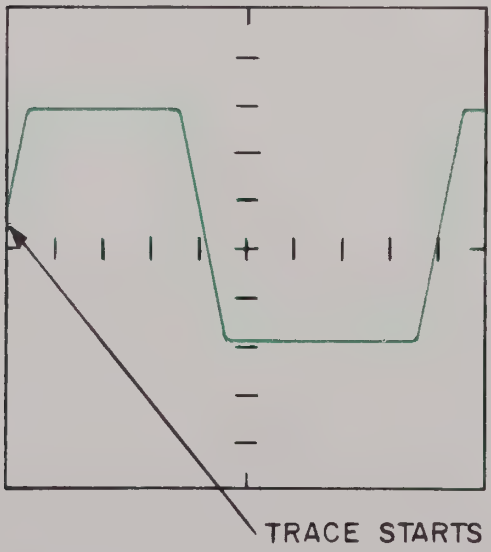


Figure 2-12. Vertical Positioning in the DC Mode

Display centered

7. Reset TRIG LEVEL control to PRESET and TRIGGER SOURCE switch to + INT.

8. Set X VOLTS/CM switch to DRIVen Sweep and rotate Y VERNIER control to give a pattern of 3 centimeters of vertical deflection. Rotate the Y POSITION control back and forth observing the left side of the display as it is positioned up and down. Notice that for any setting of the TRIG LEVEL control, the trace always starts at the same point on the waveform regardless of the setting of the Y POSITION control. See Figures 2-9 and 2-10.

Display positioned upward

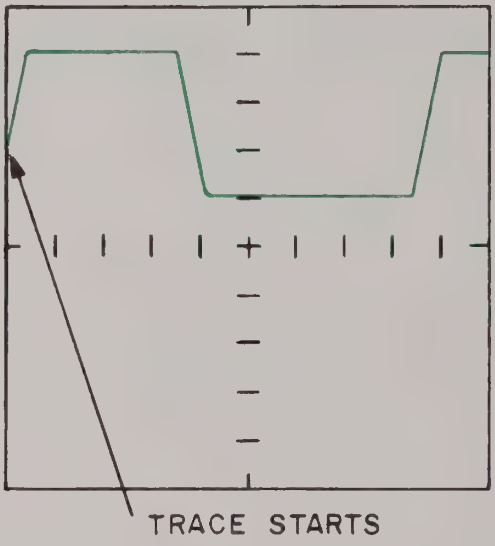


Figure 2-9. Vertical Positioning in the AC Mode

Display positioned downward

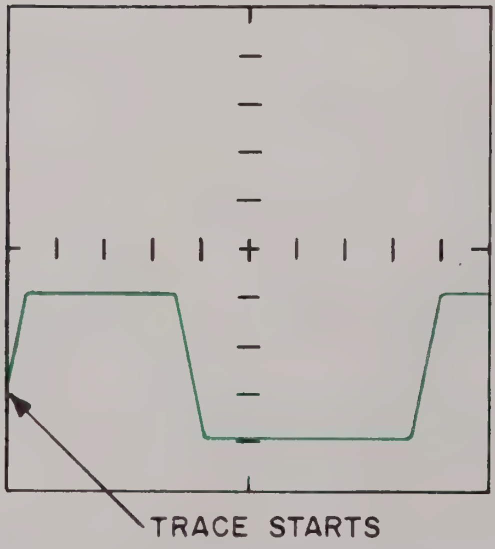


Figure 2-10. Vertical Positioning in the AC Mode

4. Consider the effect of loading upon the signal source due to the input impedance of the oscilloscope. The input impedance can be represented by a resistance shunted by a capacitance. The effective value of this resistance and capacitance is indicated on the front panel. However, the operator should be aware that even with a few feet of cable in the input circuit, the loading capacitance on the circuit under investigation might be as high as 100 pf ($\mu\mu$f) or more.

5. There are cases when connecting the input of the oscilloscope to a signal source, the effect of loading the source is not negligible. To minimize this loading, a probe may be used in the manner described in the paragraph entitled "Use of Probes".

b. Input Coupling

There are times when it is neither necessary nor desirable to display the dc component of the input waveform. A capacitor placed in series with the input connector will exclude the dc component while simultaneously permitting the ac component to be displayed. This is accomplished when either of the INPUT (AC/DC) switches or the TRIG IN switch is set to AC.

Care must be exercised when applying a fast rise, high-frequency signal to the input connector. It will be necessary to match and properly terminate the coaxial cable applying the signal to the oscilloscope.

c. Single-Ended Y Input

Signals to be observed are connected to the vertical channel through the Y INPUT terminal and ground. Y INPUT (AC/DC) switch permits capacitive or direct coupling of the signal to the compensated attenuator. The terminals for direct connection to the deflection plates are accessible at the rear of the cabinet. See Paragraph 2-16 entitled "Deflection Plate Connections" for further details.

d. Use of Balanced Input

For balanced input, remove the link from the normally grounded Y INPUT terminal. The Y VOLTS/CM switch must be set to the 0.01 DC position. If there is an in-phase signal (common mode) riding on the balanced-input signal, the permissible input voltage (dc plus peak ac) will be reduced accordingly.

One of the features of the balanced-input circuit is the differential action of the amplifier. This circuit makes it possible to reject to a considerable degree any common-mode signal, while at the same time passing and amplifying the balanced-input signal. Thus, if there is any pickup of noise on test leads or in the equipment under test, such noise will be reduced materially on passing through the balanced-input amplifier circuit. The maximum amplitude of such signals should not reach beyond ± 3V for optimum performance.

2-13. USE OF PROBES

An attenuator probe lessens both the capacitance and resistive loading caused by the oscilloscope to a minimum value. Simultaneously, while isolating the oscilloscope from the signal source, it reduces the effective sensitivity of the instrument. In other words, the displayed waveform will be reduced in amplitude by the attenuation factor of the probe. The attenuation introduced by the probe permits measurement of signal voltages in excess of those which may be accommodated by the instrument.

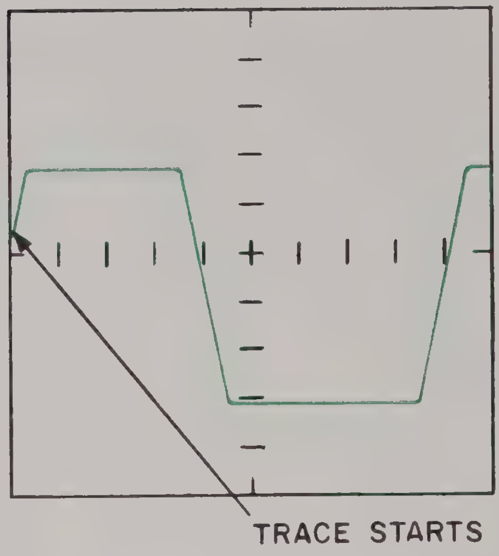
When using a probe to sample signals from a tuned, matched, or otherwise critical circuit, capacitive loading may cause erroneous readings. In these cases it may be necessary to add capacity and resistance to the circuit under observation of a value precisely equal to that of the probe impedance after the probe is removed from the circuit. This substitution will equalize loading and restore the measured characteristics of the circuit under observation.

When using the attenuator probe to make amplitude measurements, multiply the observed amplitude of the display by the attenuation factor marked on the probe.

The Du Mont Type 4290 accessory probe for the Type 401-B units, has an attenuation factor of 10 to 1. The maximum voltage that may be applied to the probe is 600 volts peak-to-peak. Voltages in excess of this value (either dc volts or peak ac volts) may cause damage to components inside of the probe housing.

IMPORTANT: Before using the probe, always check its adjustment.

An adjustable capacitor in the probe body compensates for variations in input capacitances from one unit to another. To insure accuracy in pulse and transient measurements, check the probe adjustment frequently. To check the probe, set the TRIG LEVEL control to PRESET, the TIME/CM control to 500 μs/cm, and the X



Display positioned downward

Figure 2-13. Vertical Positioning in the DC Mode

c. Summary of AC and DC Triggering Modes

In summary, the following statements may be made to compare the AC and DC modes of triggering.

1. When using the AC mode, the TRIG IN switch is set to AC, the trace always starts at the same point on the *Waveform* for a given TRIG LEVEL control setting regardless of the vertical positioning.
2. When using the DC mode, the TRIG IN switch is set to DC, the trace always starts at the same point on the *Scale* for a given setting of the TRIG LEVEL control regardless of the vertical positioning.
3. The DC mode is especially useful for viewing waveforms which change very slowly and which are therefore discriminated against by the low-frequency cutoff of the AC position (80 cps). Because of the coupling network time constant in the AC mode, signals having random repetition rates are sometimes viewed more stably in the DC mode.

2-12. OPERATING HINTS FOR THE VERTICAL DEFLECTION CHANNEL

a. Applying a Signal to the Oscilloscope

Observe the following precautions when applying signals to the oscilloscope:

1. Avoid errors in readings due to stray coupling between circuits, particularly in the signal lead. As a rule, do not use long unshielded leads for applying signals to the oscilloscope. This fact holds for the audio-frequency spectrum, except possibly when making measurements on low-impedance circuits at very low frequencies. When shielded leads are used, the shields should be grounded to the oscilloscope chassis and to the chassis of the equipment being tested. For many applications, coaxial cables are recommended.

2. In broadband applications, it may be necessary to terminate a coaxial cable with a resistance equal to its characteristic impedance. This is done to prevent standing waves or ringing (high-frequency damped oscillations). As the length of the cable is increased, the necessity for proper termination is generally inserted at the oscilloscope end of the cable, although many signal sources may require an additional termination at the other end of the cable. Refer to the accessory section of your Du Mont catalog for a listing of cables, terminating resistors and pads.

3. To avoid erroneous results, the operator should simulate the actual operating conditions of the equipment being tested. For example, the equipment should work into a load impedance equal to that which it will see in actual use.

single trace being superimposed on one another. Simply turning the X VOLTS/CM switch to the SINGLE position, eliminates the overlapping caused by the multiple traces and enables the display to be viewed and/or recorded clearly.

1. INTERNAL RESET
   A single trace will sweep across the screen each time the sweep is triggered. At the end of its travel, the beam will rest off screen, and the right beam position indicator, with RESET lettered beneath it, will light indicating that the sweep requires rearming (resetting). To rearm the sweep, turn X VOLTS/CM switch from SINGLE to RESET and back to SINGLE position. The indicator light will go out indicating the sweep is armed and ready to fire on the next trigger.

2. EXTERNAL RESET
   The sweep may be armed remotely by means of a contact closure introduced through the two-contact socket located on the rear of the instrument. See Figure 2-15.

   The Du Mont Type 4001 Sweep Rearming Kit is available as an accessory for remote rearming of the sweep. All the necessary parts and complete instructions for installation and operation will be supplied with the kit.

d. Sweep Expansion (Uncalibrated)

When the X VERNIER control is set fully clockwise but with its switch *not* actuated, sweep expansion about the center of the sweep up to a ratio of 5:1 (uncalibrated) may be obtained. Under this condition, using the X POSITION control enables any portion of the expanded sweep to be displayed on the screen.

e. Sweep Expansion (Calibrated)

1. To calibrate expanded sweep, proceed as follows:

   Set the following controls to position indicated:

CONTROL	POSITION
Y VOLTS/CM	CAL
X VOLTS/CM	AUTO
X VERNIER	CAL
TIME/CM	10 MS/CM
TRIGGER SOURCE	+ INT
TRIG LEVEL	PRESET

2. Adjust TIME/CM VERNIER control to obtain a display of 10 cycles full scale of the calibrated waveform.
3. Adjust X VERNIER control to obtain a display of only 2 cycles full scale. The Sweep Expansion is now 5:1.
4. Changes in sweep time and sweep vernier settings and changes in mode of sweep operation (Driven, Auto, Single) will not effect the calibration. Care must be exercised not to accidentally move the X VERNIER control from the previous setting.

f. Obtaining Lower Sweep Writing Rates

Obtaining lower sweep wirting rates than are provided for in the instrument is accomplished by using external sweep capacitors.

The lowest sweep rate available in this instrument without using external sweep capacitors is 10 seconds full scale or 1 second/cm with the TIME/CM switch set to 200 and the TIME/CM VERNIER control set fully clockwise. To make connections for lower sweep rates, proceed as follows:

CAUTION

THE EXT SWP CAP TERMINALS ARE 150 to 250 VOLTS ABOVE GROUND

1. Turn power off.
2. Remove cover on rear of unit to gain access to EXT SWP CAP terminals.
3. Connect external capacitor.
4. Replace cover.

The sweep rate will be reduced by 2:1, that is, from 1 second/cm to 2 seconds/cm by addition of a 0.12 μf 200-volt capacitor. Refer to Figure 2-14 to determine other values of external capacitance and sweep rate.

VOLTS/CM switch to AUTO. Apply the probe tip to the GATE OUT connector. Adjust the probe capacitor for a flat trace on the screen.

To preserve the waveform of the signal being displayed, clip the probe ground lead to the chassis of the equipment being tested. Select a short clean ground point near the probe input connection.

2-14. OPERATING HINTS FOR THE SWEEP CHANNEL

a. Automatic Sweep

In some applications, it is desirable to have the sweep free-running, whether synchronized or not. When using the AUTO mode, a horizontal reference trace will appear on the screen, even in the absence of an input signal. This AUTOmatic mode is very useful while testing equipment since a reference trace will always be visible during the time no signal is applied to the oscilloscope. The AUTO mode simplifies synchronization of signals having repetition rates greater than 50 cycles and is useful while observing periodic waveforms.

To obtain AUTOmatic sweep operation, set controls as outlined under paragraph entitled "Driven Sweep", except turn X VOLTS/CM switch to AUTO position.

b. Driven Sweep

A stable pattern for practically all types of signals can be obtained by using driven sweep. Its use is mandatory for viewing random or nonperiodic signals of low-duty cycle. When operating the instrument in this manner, one sweep occurs for each single impulse. Use of the driven sweep mode of operation in the majority of applications, is the condition under which optimum performance can be expected of this equipment.

When the oscilloscope is set for DRIVen Sweep, the spot will be visible only during forward sweep time. The INTENSITY control must be properly adjusted to make the sweep visible. Intensity should not be set so bright as to override the retrace blanking. For driven sweep operation, follow the procedure outlined below.

1. Set front-panel controls as follows:

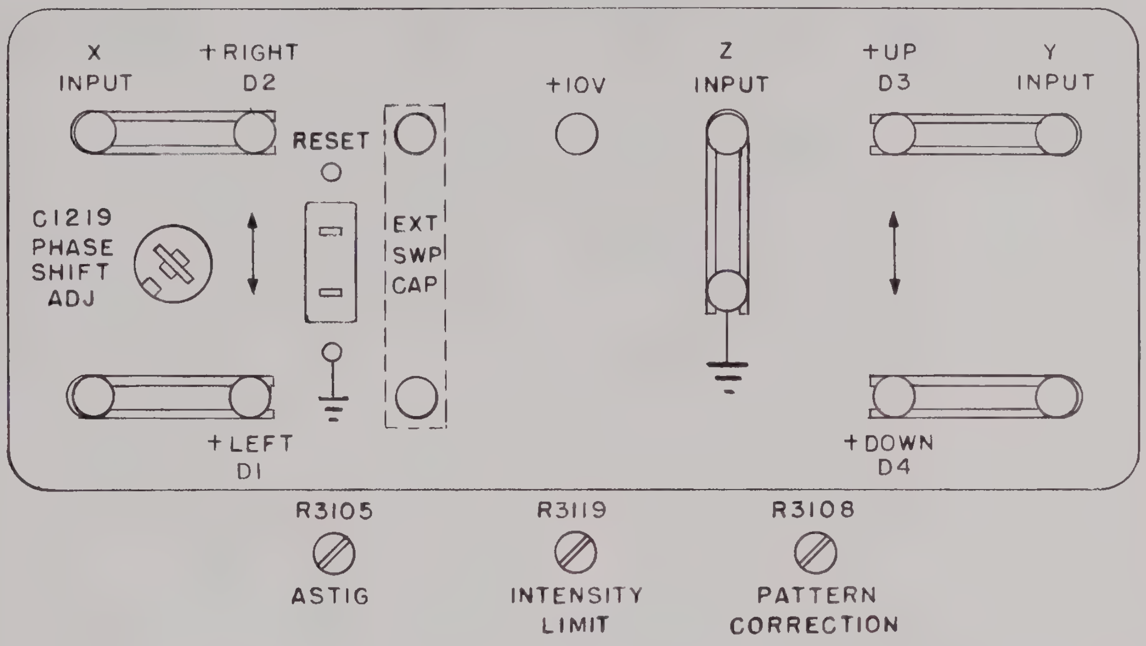
CONTROL	POSITION
X VOLTS/CM	DRIVen Sweep
Y VOLTS/CM	Set as determined by amplitude of signal source or at 0.01
VERNIERS (all three)	CAL
TRIGGER SOURCE	+ INT

2. Apply desired signal to Y INPUT.
3. Adjust TRIG LEVEL control to initiate the sweep and the POSITION controls to center the pattern.
4. Adjust Y VERNIER control in conjunction with Y VOLTS/CM switch to obtain a vertical deflection of approximately 5 centimeters.
5. Adjust X VERNIER control to expand the trace. If display tends to move off screen, adjust the X BAL control to position it back on screen.
6. Rotate the TIME/CM and VERNIER controls to obtain the desired number of cycles. Readjust TRIG LEVEL control if necessary.
7. Adjust INTENSITY and FOCUS controls to obtain a sharp trace of suitable brightness.
8. If there is any multiple triggering of the sweep, the TRIG LEVEL control may be adjusted to select the signal levels which will best actuate the trigger circuit. Thus, undesirable signals of lesser amplitude will not affect the sweep.

c. Single-Sweep Operation

In a majority of applications, a repetitive sweep is used. However, when it is desired to view a single display which continually varies in amplitude, shape, and time, the X VOLTS/CM switch should be set to SINGLE, for single-sweep presentation. Single-sweep operation infers that the time base moves but one stroke until reset. Reset may be accomplished by setting the X VOLTS/CM switch to RESET, or through external contact closures.

Using a repetitive sweep to view a varying waveform would result in an overlapped and unintelligible display caused by many cycles of the



NAME	FUNCTION
EXT SWP CAP	Provides connection for external sweep capacitor when TIME/CM switch is set to its 6 slowest sweep rate settings. These terminals are at + 150 to + 250 volts.
X INPUT	Terminals D1 (left) and D2 (right) provide direct connection of signals to the horizontal deflection plates with jumpers removed. The two terminals on extreme left are the output of the horizontal amplifier and are connected by jumpers to the horizontal deflection plate terminals D1 and D2. These terminals are at a + 245V dc level.
Y INPUT	Terminals D3 (UP) and D4 (DOWN) provide direct connection of signals to the vertical deflection plates with jumpers removed. The two terminals on extreme right are the output of the vertical amplifier and are connected by jumpers to the vertical deflection plate terminals D3 and D4. These terminals are at a + 245V dc level.
Z INPUT	Provides connection for external signals for intensity modulation of the trace.
PHASE SHIFT CAP	Provides adjustment for zero phase differential between the X and Y amplifiers.
+ 10V	Screw terminal providing a high impedance dc voltage to facilitate triggering from external contact closures.
ASTIG	Provides voltage adjustment for the cathode-ray tube to optimize spot shape.
INTENSITY LIMIT	Adjusted to limit brightness level with main Intensity control.
PATTERN CORRECTION	Adjused to minimize pattern distortion.
RESET	Du Mont Accessory Type 4001. Supplied as kit to enable sweep to be armed remotely by means of a contact closure introduced through the two-contact socket.

Figure 2-15. Function of Rear-Panel Facilities

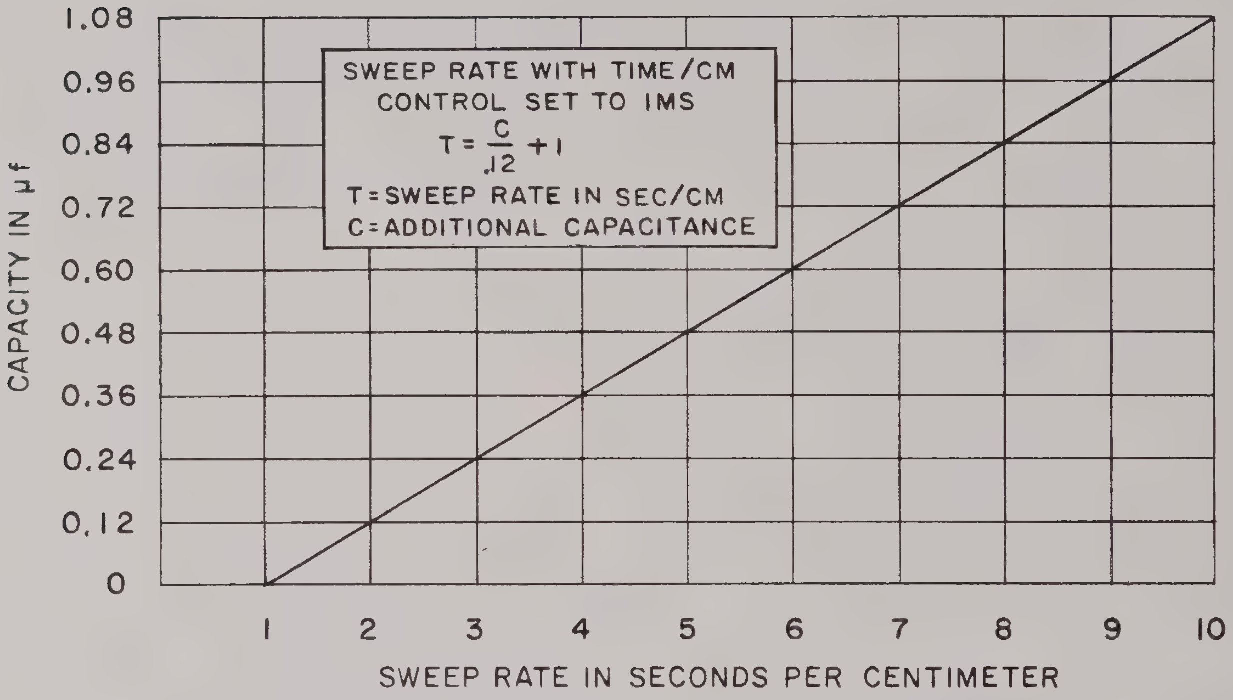


Figure 2-14. Additional Capacitance Versus Sweep Rate

The addition of the external sweep capacitance will affect the sweep rate for the 6 longest positions of the TIME/CM switch, extending each range by the factor: $\frac{C}{0.12} + 1$ (See Figure 2-14).

A high-leakage-resistance capacitor of the best quality is recommended. Ordinary paper capacitors have high temperature coefficients and poor recovery characteristics. The results obtained in extending the sweep range will depend entirely on the quality of the external capacitor.

g. Reduction of Expanded Sweep to Zero

In order to reduce sweep amplitude to zero when the VERNIER control is set fully counterclockwise, the following modification should be made.

Short out resistor R1214, located on the X VERNIER control R1215.

When this modification has been performed, care must be exercised to avoid overloading the X amplifier when being used for X-Y plotting.

2-15. REAR-PANEL FACILITIES

With one exception, the rear-panel facilities on both the Types 401-B and 401-BR are identical. In the 401-BR rack model, the front panel binding posts are duplicated in the rear of the instrument. Two slide switches are provided on the front panel of the rack-mounted version, one in the X and one in the Y circuit. When positioned to the left, the front binding posts are connected to the specific amplifier and the rear terminals are out of the circuit. When positioned to the right, the rear binding posts are connected to the specific amplifier and the front terminals are out of the circuit.

Adjustment procedure for ASTIG, INTENSITY LIMIT, and PATTERN CORRECTION controls is explained in Section 4 of this manual.

2-16. DEFLECTION PLATE CONNECTIONS

a. General

When applying signals to deflection plates, the highest frequency signal that can be observed is not limited by the response of the built-in amplifiers, but is dependent upon the input capacitance to the deflection plate terminals and/or transit time of the electrons between the deflection plates. Provided the impedance of the signal source is kept low, transit time is the only consideration. It should be remembered however, that no amplification or attenuation is provided on direct input. See Table 1-1 for deflection sensitivities.

1. Disconnect the appropriate CRT deflection-plate links from their terminals.
2. Remove links on Amplifier terminals and bridge each pair of terminals with a series resistor (4.7 megohms) in each leg.
3. Connect the signal through blocking capacitors of at least 600 volts dc rating.
4. To avoid any possibility of cross-coupling effects, it is suggested that when connecting a signal direct to deflection plates, the corresponding channel (X VOLTS/CM and/or Y VOLTS/CM) controls be switched to OFF.

2-17. INTENSITY (Z AXIS) MODULATION

Positive signals applied to Z INPUT will decrease the beam intensity. To make connection for intensity modulation of the trace, turn power off, remove link and apply intensity modulation signal to the Z INPUT. Connection to the Z INPUT applies the signal between the CRT cathode and ground. A positive signal of 15 volts will cause sufficient blanking. The Z INPUT presents an impedance of 10,000 ohms and 30 pf ($\mu\mu f$) to the signal source, coupled through a 0.01 capacitor.

Always reconnect the link between the Z INPUT terminals when not using external intensity modulation.

2-18. VOLTAGE MEASUREMENTS

a. General

The Du Mont Types 401-B and 401-BR Oscilloscopes may be used to measure the voltage of the input signal by using the calibrated VOLTS/CM setting and observing the height of the display on the screen in centimeters.

When making voltage measurements, the operator should try to set up the instrument for full scale vertical deflection to insure maximum accuracy. Also, it is important to remember that the width of the trace may be an appreciable part of the over-all measurement. This is particularly true when you are measuring signals of small amplitude or when stray signal pickup has broadened the trace. The operator should consistently make all measurements from one side of the trace. If the top side of the trace is used for one reading, it should be used for all succeeding readings.

b. How to Measure Peak-To-Peak Voltages Using the CRT Scale

The procedure employed for all voltage measurements is basically the same. The Y VERNIER control must be switched to CAL. The specific examples that follow are intended to show the general procedure. These examples may be adapted to fit any particular application.

To measure the ac component of the signal on display, set the Y INPUT (AC/DC) switch to AC. In this position, only the ac components of the input signal are displayed on the screen. However, when the ac component of the input is of very low frequency (under 10 cps), set the Y INPUT (AC/DC) switch to DC to prevent errors. To make measurements, proceed as follows:

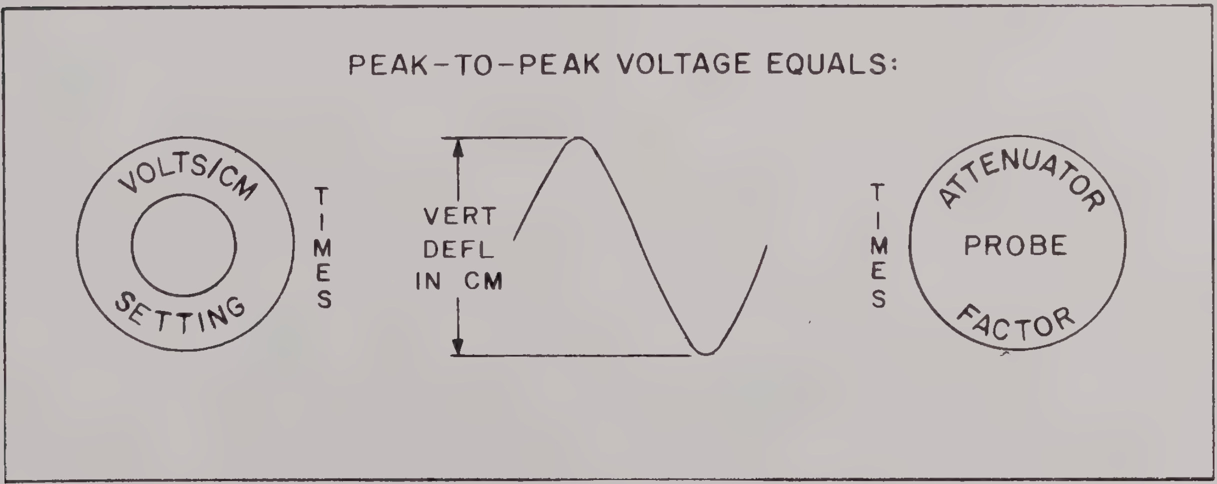


Figure 2-17. Peak-to-Peak Voltage Measurement

b. Direct Deflection Plate Connections

CAUTION
BEFORE MAKING CONNECTIONS, TURN POWER OFF

Direct connection to the deflection plates is made by removing links on deflection plate terminals. See Figure 2-15, and note the following:

1. External deflection plate return resistors must be provided, when using AC coupling and internal positioning.
   Single-ended input, 5 megohms (maximum) either plate to ground; balanced input, 10 megohms (maximum) center-tapped to ground.
2. When using DC coupling, the average dc potential of approximately 245 volts above ground should be preserved on both pairs of deflection plates for best focus; however, the astigmatism adjustment (R3105) has sufficient range for potentials from 200 to 300 volts.
3. This average dc level should be made adjustable to provide an astigmatism control for optimum focus adjustment.
4. A loss of positioning will occur. To retain front-panel control of positioning, follow steps outlined in next paragraph.

c. Obtaining Positioning Voltage

Removing the links when making direct connections to the deflection plates also removes the positioning voltage, making the front panel position controls inoperative. To retain front panel control of positioning, follow the steps as outlined and refer to Figures 2-15 and 2-16.

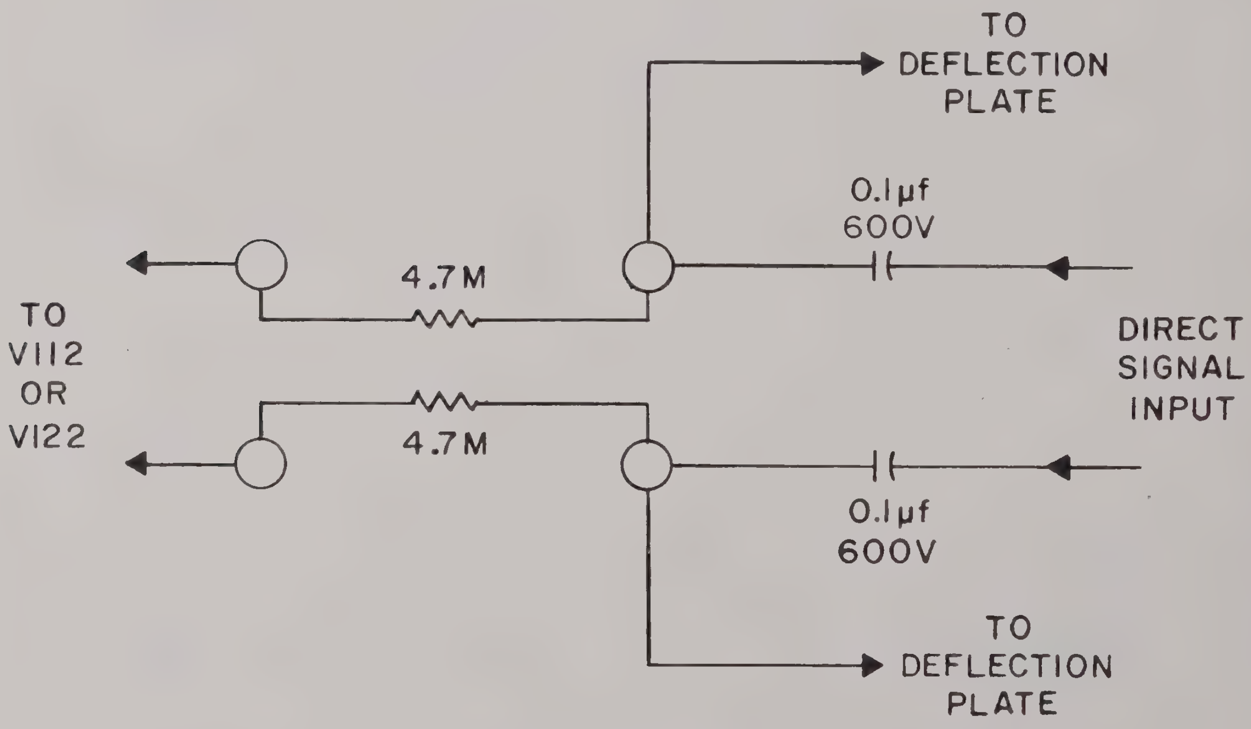


Figure 2-16. Circuit for Retaining Front Panel Control of Beam Position when Using Direct Signal Input

6. Using the calibrated scale, measure the vertical deflection in centimeters from the desired point on the waveform to the pre-established reference line set up in Step 3. See Figure 2-18.

7. Multiply the vertical dimension obtained in Step 6 by the VOLTS/CM control setting to obtain the indicated voltage.

8. Multiply the indicated voltage obtained in Step 7 by the attenuation factor of the probe used to obtain the actual instantaneous voltage.

For example, suppose that you are using a 10:1 attenuator probe and the VOLTS/CM control is set to 0.1. Assume that the vertical distance between the desired point on the waveform to the pre-established reference line is 4 centimeters. Now, multiply this vertical deflection of 4 centimeters by the VOLTS/CM setting of 0.1 to give 0.4 volt. Next, multiply this result by 10, the attenuation factor of the probe. This shows that the instantaneous voltage with respect to ground to be 4 volts. Since the voltage point is above the reference line, the indicated polarity is positive.

2-19. TIME MEASUREMENTS

a. How to Make Elapsed Time Measurements Using the CRT Scale

Any horizontal distance on the screen of the oscilloscope can be used to represent a precise interval of time, when the time-base circuits are set up for calibrated sweep (Time Vernier in Cal position). Use of this feature permits you to accurately measure the elapsed time between the desired point of interest on the display. To measure the time interval, proceed as follows:

1. Using the calibrated scale, measure the horizontal distance in centimeters between that portion of the display whose time in-interval you wish to find.

2. Multiply the horizontal dimension obtained in Step 1 by the TIME/CM control setting to obtain the time interval. See Figure 2-19.

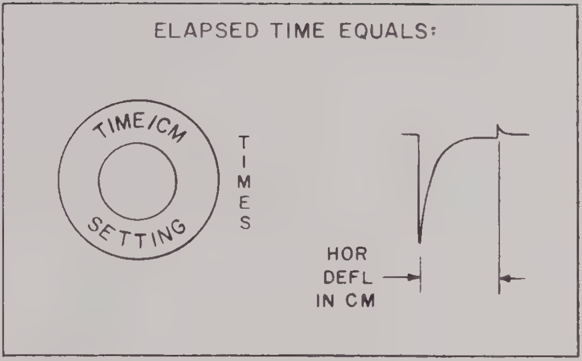


Figure 2-19. Elapsed Time Measurement

b. How to Find Repetition Rate or Frequency Using the CRT Scale.

The repetition rate or frequency for periodic signals can be expressed as the number of cycles or pulses per unit of time. To use the oscilloscope for measuring the repetition rate or frequency of periodic signals, proceed as follows:

1. Using the calibrated scale, measure the horizontal distance in centimeters occupied by one cycle of the display under observation.

2. Multiply the horizontal dimension obtained in Step 1 by the TIME/CM control setting.

3. Take the reciprocal of the product obtained in Step 2 (that is, divide it into one). The resulting quotient is the desired frequency or repetition rate in cycles per second. See Figure 2-20.

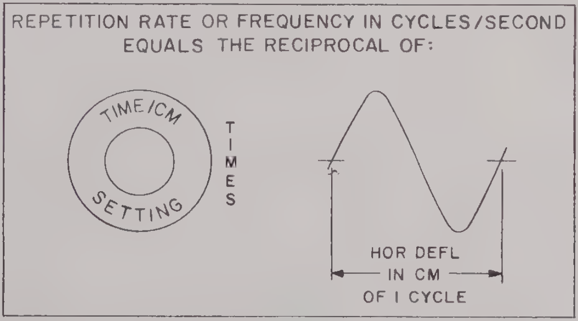

REPETITION RATE OR FREQUENCY IN CYCLES/SECOND
EQUALS THE RECIPROCAL OF:
TIME/CM
SETTING
TIMES
HOR DEFL
IN CM
OF 1 CYCLE

Figure 2-20. Finding the Frequency

1. Using the calibrated scale, measure the vertical deflection in centimeters from the positive peak to the negative peak of the waveform. See Figure 2-17.
2. Multiply the vertical dimension obtained in Step 1 by the VOLTS/CM control setting to obtain the indicated voltage.
3. Multiply the indicated voltage obtained in Step 2 by the attenuation factor of the probe, if one is used, to obtain the actual peak-to-peak voltage.

For example, suppose that you are using a 10:1 attenuator probe and the VOLTS/CM control is set to 0.1. Assume that the vertical distance between the peaks of the waveform measures 4 centimeters. Now, the vertical dimension of 4 centimeters is multiplied by the VOLTS/CM setting of 0.1 to give 0.4 volt. Next, multiply this result by 10, the attenuation ratio of the probe. This gives 4 volts as the peak-to-peak voltage of the display waveform.

c. How to Measure Instantaneous Voltages With Respect to Ground (or Some Other Reference Potential) Using the CRT Scale

The technique used for measuring instantaneous voltages with respect to a reference point, is virtually the same as that described for peak-to-peak voltage measurements. The difference is that now a reference point must be established on the screen of the oscilloscope. Since voltage measurements with respect to ground are the most common, the procedure which follows, establishes ground as the reference point. The same general technique may be used for instantaneous measurements with respect to any other potential, just so long as that potential is employed to establish the reference point.

To make measurements, proceed as follows:

1. Set the Y INPUT (AC/DC) switch to DC.
2. Set the TRIG LEVEL control to PRESET.
3. To establish the reference point, touch the probe tip to the ground on the oscilloscope (or to the desired source potential) if a point other than ground is used).
   Vertically position the trace to a convenient point on the screen. This point should be chosen so that it lies on one of the major horizontal scale divisions. The chosen horizontal scale line, which is now coincident with the trace, is the reference line from which all voltage measurements are to be made.
4. Disconnect the probe tip from ground and connect it to the signal source without disturbing the POSITION control.
5. Adjust the oscilloscope controls for a suitable and stable display.

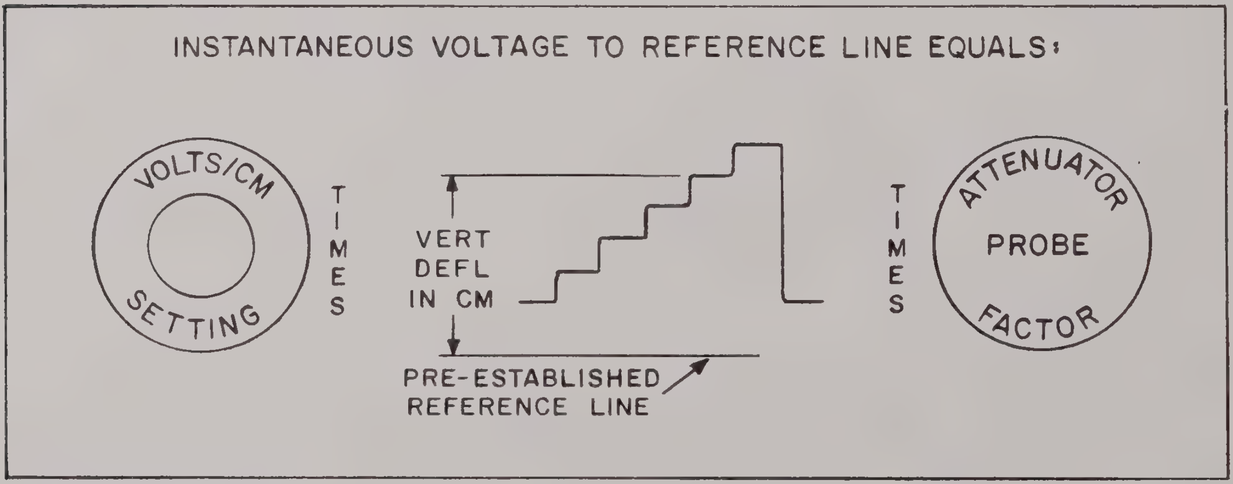


Figure 2-18. Instantaneous Voltage Measurement with Respect to Ground (or Some Other Reference Potential)

section 3
circuit description

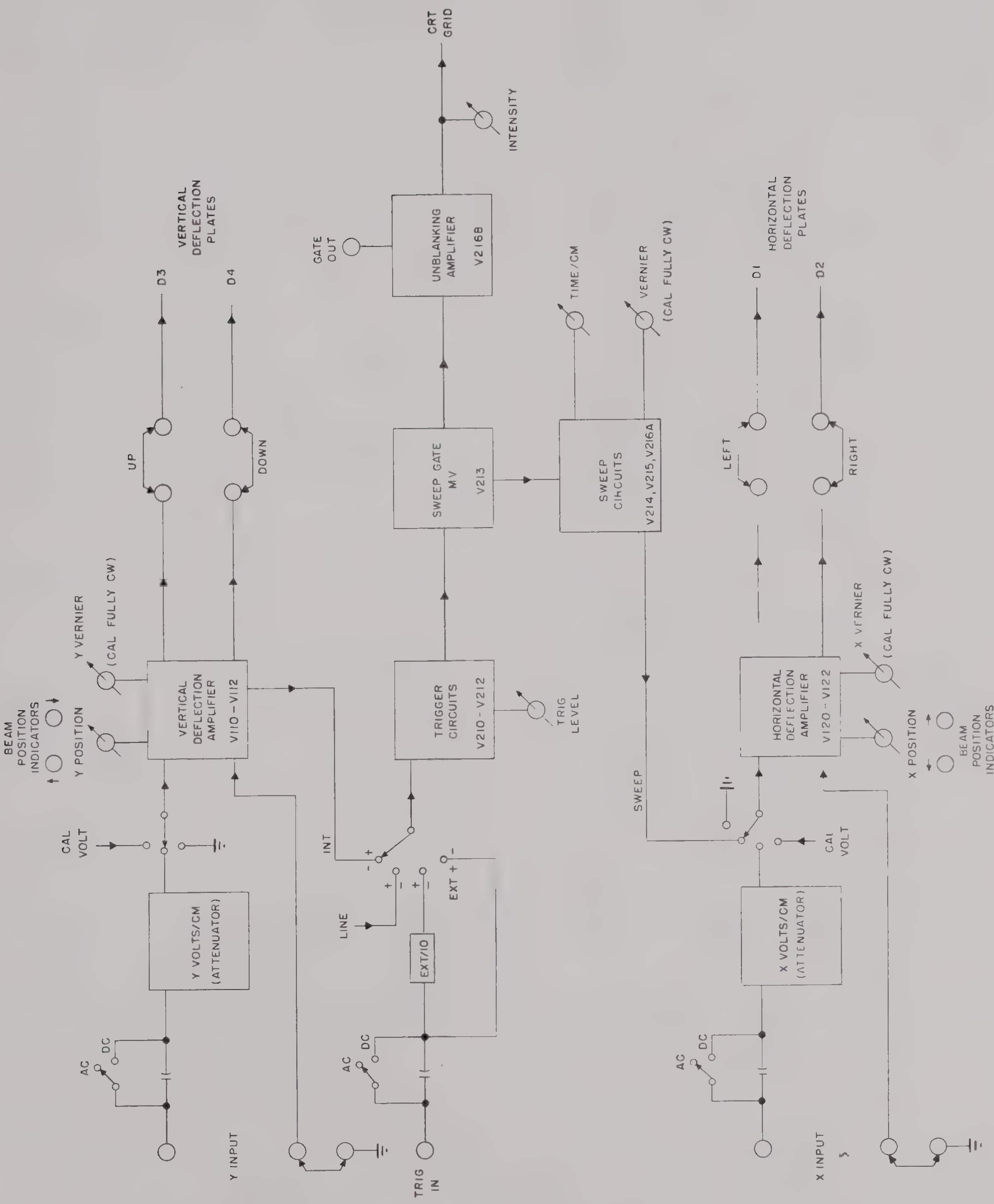


Figure 3-1. Du Mont Type 401-B/401-BR Oscilloscope, Simplified Block Diagram

2-20. RISE-TIME MEASUREMENTS

Application of signals from an external time calibrator will facilitate pulse rise-time measurements. When making such measurements, the one factor which must be borne in mind for most accurate quantitative results is the pulse response characteristic of the vertical amplifier. This characteristic is related to the observed pulse rise time and the actual pulse rise time in the following manner:

$$t_p = \sqrt{(t_o)^2 - (t_a)^2}$$

Where: t_p = actual pulse time in microseconds

t_o = observed rise time of pulse in microseconds

t_a = amplifier rise time in microseconds

Once the amplifier rise time is known (see Table 1-1), the rise time of any pulse may be calculated.

To make rise-time measurements, proceed as follows:

1. Adjust pattern for full scale (10 cm) of vertical deflection.
2. Using the X and Y POSITION controls, adjust the display vertically so that the start of the waveform rests 1 centimeter below the scale horizontal center line and the rising portion of the waveform intersects the zero point on the scale (labeled A in Figure 2-21). Observe that the top of waveform is off screen. Be careful not to accidentally change the setting of the X POSITION control.
3. With the Y POSITION control, move the waveform down until the top portion of the waveform rests 1 centimeter above the horizontal center line.
4. Note where the rising portion of the waveform intersects the X axis (labeled B in Figure 2-21).

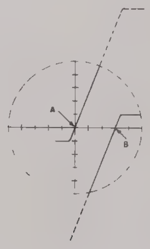


Figure 2-21. Rise-Time Measurement

5. Measure the distance between points A and B; multiply this reading by the TIME/CM switch setting to obtain rise time.
6. For example, if the distance between points A and B is 3 centimeters and the TIME/CM switch is set to 5 μs, the rise time would be 15 μs.
7. Rise-time measurements made in this manner eliminate errors which would result from improper deflection plate alignment and incorrect interpolation.

2-21. PHASE SHIFT MEASUREMENTS

Phase measurements are usually made when the frequencies of the two input ac signals are equal. Hence Lissajous figures that result from a phase difference between two input signals of the same frequency are often referred to as phase difference patterns. When the frequencies of the two input signals are not a 1:1 ratio, the Lissajous figures are generally used for frequency measurements.

To check the relative phase shift, proceed as follows:

1. Apply a sine wave signal to both the X and Y INPUT.
2. Center the trace horizontally and adjust the Y controls for 10 centimeters of vertical deflection. The pattern obtained should be similar to Figure 2-22.
3. The angle between the two signals is that angle whose sine is the ratio of A/B.

   Note: To obtain full scale vertical deflection of 10 centimeters, it may be necessary to temporarily reduce the horizontal amplitude of the display. To accomplish this, set the X VOLTS/CM switch one step counterclockwise from its initial setting. Adjust the display for 10 centimeters of vertical deflection. Reset X VOLTS/CM switch to its original setting, recenter the display and read dimension A in Figure 2-22.

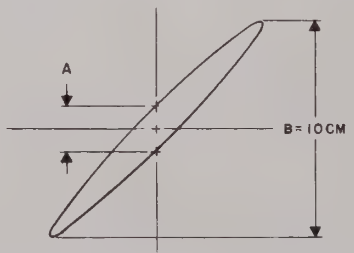


Figure 2-22. Phase Shift Measurement

good deflection amplifier stability. The input dc amplifier, V101 (which on balanced inputs, acts effectively as a differential amplifier) precedes the continuously variable Y VERNIER control R1115.

The normally grounded grid of V110B is brought out to the front-panel binding post, J1102, so that balanced input operation may be obtained simply by removing the ground link between J1102 and J1103. The RC Networks R1107 and C1109; and R1108 and C1111, in series with the grids of V110 serve to protect the input circuit from damage due to excessive input voltage. The shunt capacitors preserve the high-frequency signal components.

The Y BAL front-panel screwdriver control, R1111, equalizes the voltages at the ends of the Y VERNIER control. When this control is properly set, there will be no shifting (up and down) of the trace when Y VERNIER control is rotated throughout its range with no signal applied to the amplifier. When the Y VERNIER control, R1115, is switched fully clockwise, the amplifier is set for calibrated operation. The Y CAL front-panel screwdriver control, R1117, is used for normalizing the gain of the vertical deflection amplifier.

The Y DP LEVEL ADJ, R1121, is provided to set the deflection plate voltage of the cathode-ray tube so that the output of the internal trigger divider is at ground when the beam is centered.

For amplitude measurements, an internal calibrating voltage is applied to the vertical input dc amplifier, V101B, when the VOLTS/CM switch is set to CAL. This switch automatically disconnects the Y INPUT signal from the amplifier when the calibrator signal is applied. The output of V112 is applied to the vertical deflection plates. Two neon lamps, DS1101 and DS1102, are connected across the vertical deflection plates and biased slightly below these plates. These lamps indicate which direction the spot is off the screen if it cannot be seen. If either plate assumes a voltage much higher than the average voltage, the beam position indicator connected to that plate will be lit.

3-3. HORIZONTAL DEFLECTION AMPLIFIER

Since identical vertical and horizontal amplifiers are employed in the Types 401-B and 401-BR, the previously discussed theory for the vertical amplifier is equally applicable, except for the X VOLTS/CM switch. By means of the X VOLTS/CM switch, provision is made for the selection of internal or external signals for horizontal deflection. The internal signal is obtained from the sweep circuits described elsewhere in this Section. External signals may be applied to the X INPUT terminals. The X DP LEVEL ADJ is used to set the X deflection plate average potential equal to the Y DP average potential.

A phase shift trimmer, C1219, is added across the output of the horizontal deflection amplifier, V122, so that zero phase differential (between the X and Y amplifiers) may be obtained at the upper frequency limits specified. Provision is made for direct input to both the vertical and horizontal deflection plates. See Paragraph 2-16 for use of this feature.

3-4. TRIGGER CIRCUIT

a. Trigger Amplifier and Level Selector

The TRIGGER SOURCE switch selects the source of the triggering voltage and arranges the trigger amplifier input, V210, to trigger on the negative-going or positive-going portion of the triggering signal.

The trigger amplifier, V210, is a cathode-coupled amplifier. By means of the TRIG IN switch S211, capacitor C2104 can be switched into the grid circuit to remove the dc component of the trigger signal. Output is always taken from the A-Section plate, but the TRIGGER SOURCE switch S210, connects either the A-Section grid or the B-Section grid to the input trigger source. The latter action permits trigger polarity selection.

For positive-going signals, connection is made to the grid of V210A, and for negative-going signals, connection is made to the grid of V210B. In each case, the opposite grid is connected to a dc bias source, adjustable by means of the TRIG LEVEL control R2106.

The TRIG LEVEL control is used to select the level of the triggering point for all settings of the TRIGGER SOURCE switch. A PRESET position is provided on the TRIG LEVEL control to simplify operation and to optimize trigger channel sensitivity.

The TRIG LEVEL CENT adjustment, R2113, sets the level of V210 so that no readjustment of the TRIG LEVEL control is required when the TRIGGER SOURCE switch is set from plus to minus slopes or vice versa. This adjustment is made with the TRIG LEVEL control in the PRESET position.

SECTION III

CIRCUIT DESCRIPTION

3-1. GENERAL (Figure 3-1)

To simplify circuit analysis, the instrument can be divided into five basic sections as follows: (1) Vertical Deflection System; (2) Horizontal Deflection System; (3) Sync Circuit; (4) Sweep Circuit; and (5) Regulated LV and HV Power Supplies. The circuit description will be keyed to the functional block diagram, Figure 3-1. Emphasis is placed on the inter-relation of circuits rather than on detail of operation. It is also recommended that the Schematics at the rear of this Manual be referred to in following the circuit description.

3-2. VERTICAL DEFLECTION SYSTEM

a. Input Circuit

The Y VOLTS/CM switch selects the desired attenuation of the input signal in decade steps from 0.01 volt to 10 volts/centimeter. The OFF position of this switch removes the input signal from the attenuator and grounds the grid of the input dc amplifier V110.

The AC/DC switch inserts a blocking capacitor in series with the Y INPUT connector in the AC position and removes it in the DC position.

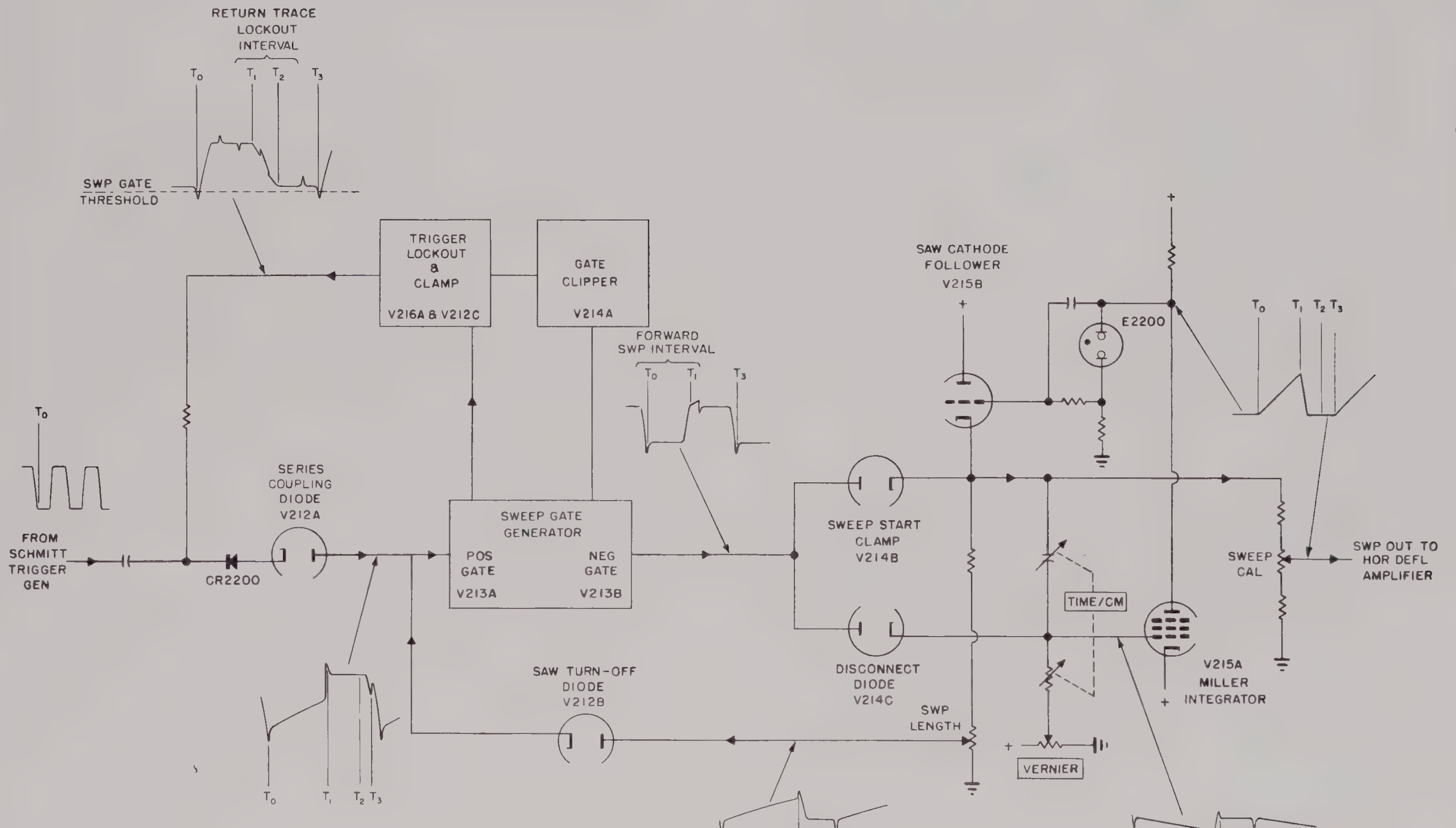
The front panel input terminals are duplicated at the rear of the rack-mounted unit. Front/rear switching is possible on the front panel to allow choice of either front or rear connection.

The input decade attenuators are RC compensated to maintain frequency and phase response and to present an impedance of 1.0 megohms in shunt with 47 pf ($\mu\mu$f) nominal to the circuit under test, regardless of the attenuation selected.

Provision is made for applying a balanced signal to Y INPUT when the Y VOLTS/CM switch is set to the DC 0.01 Volt/cm position. For details on use of this feature, refer to Section 2, Operation.

b. DC Amplifier Operation

The vertical deflection dc amplifiers comprise V110 through V112 inclusive. Regulated dc heater voltage is supplied for the first two stages. The dc balanced circuit arrangement provides



T_0 = TRIGGERED INITIATION OF TIME BASE.
T_1 = TURN-OFF OF TIME BASE.
T_2 = END OF LOCKOUT INTERVAL.
T_3 = SAME AS T_0.

Figure 3-2. Sweep Generator, Simplified Diagram

b. Schmitt Trigger Generator

The Schmitt Trigger Generator is essentially a regenerative signal amplitude selector. It consists of a two-stage amplifier, V211A and V211B, having dc plate-to-grid coupling from A to B amplifier and dc cathode-to-cathode coupling. The circuit has two stable states: the A side conducting, the B side at cutoff; the B side conducting, the A side at cutoff. The transition from one state to the other is abrupt, producing fast rise and fall times from each side of the circuit.

The dc voltage applied to the grid of V211A determines which state the circuit will be in. Assume operation as follows: V211A is conducting and V211B is at cutoff. V211B will remain at cutoff until the amplitude of a positive-going signal applied to its grid, reaches the threshold level of conduction. When this threshold level is exceeded, an abrupt transition from cutoff to full conduction will occur in V211B. Simultaneously, V211A will promptly stop conducting. V211A and V211B will revert to their original condition when the amplitude of the initiation signal falls slightly below the threshold level of conduction for V211B.

In general, the threshold voltage is higher when moving the grid in a positive direction, and lower when moving the grid in the negative direction. The two different voltage levels are called the upper and lower hysteresis limits of the Schmitt Trigger Generator.

The initial A-side grid level can be positioned anywhere inside or outside of the hysteresis area, thus establishing the input voltage required to change the state of V211A. The steady state grid bias of V211A is normally determined by the TRIG LEVEL control setting.

When the X VOLTS/CM switch is set to AUTO, the trigger amplifier is ac coupled to the input grid of the Schmitt Trigger Generator through C2108 and the feedback resistor R2126, is connected between the grids of the Schmitt Trigger Generator. This causes V211A and V211B to flip back and forth, yielding about 50 pulses per second. Thus, a horizontal reference trace will appear on the screen even in the absence of an input signal.

3-6. LOW-VOLTAGE POWER SUPPLY

a. Power Transformer

Plate and heater power for this instrument is provided by a single power transformer, T3200. The primary is wound with two equal 115-volt windings that can be connected either in parallel for 115-volt operation, or in series for 230-volt operation. The secondary contains two separate high-voltage windings and four separate heater windings.

b. Regulated Supplies

Three regulated positive supplies and one regulated negative supply are provided with outputs as follows: +390 volts, +150 volts, +85 volts, and —50 volts.

The +85-volt regulated output is provided by gas diode, V323, and is also the voltage reference source for the other low-voltage regulated supplies.

Operation of the other low-voltage regulated supplies is identical, so only the +390-volt supply is described. V321 is connected in a conventional full-wave rectifier circuit. The rectified output is capacitively filtered by C3211 and C3212. Three capacitors are shunted by resistors R3221 and R3222 to equalize the voltage across them.

The filtered rectified output is applied to V324A, a series passing tube whose series resistance is adjusted by the sample fed back from R3234F through the dc amplifier V322A to its control grid. If the +390-volt output changes due either to a change in input voltage or load current, the sample voltage changes and alters the passing tube grid to return the output to +390 volts.

c. Voltage Calibrator

The power-line frequency voltage from T3200 is applied to the voltage calibrator, V320, through limiting resistor R3200. With the plate of V320A tied to ground, any negative voltage impressed on this section will cause conduction, thus clamping the negative half-cycle at approximately ground potential. On the positive half cycle, conduction occurs in the other half section, V320B, when the peak applied potential exceeds +150 volts, thus clipping the sine wave at that point. The resulting trapezoidal waveform is applied to a voltage divider R3203, R3205, and C3200. The attenuated output is coupled to the vertical and/or horizontal amplifier when the appropriate VOLTS/CM switch is set to CAL.

3-7. HIGH-VOLTAGE POWER SUPPLY

Accelerating voltages for the cathode-ray tube are obtained by rectifying a 60 Kc high voltage produced by a vacuum-tube oscillator. V313 is the oscillator tube connected as a Hartley oscillator with the primary of transformer T3100 as the tapped inductor, and C3113 as the capacitor.

A conventional half-wave rectifier, V310, supplies the necessary voltage for the post-deflection accelerating anode of the cathode-ray tube. Operating potentials for the proper intensity and focusing of the cathode-ray tube are derived from the regulated supply. Regulation is accomplished by sampling a portion of the rectified output and applying a correction signal back through V314 to the screen grid of V313.

Two rectifiers, CR3101 and CR3102, furnish cathode and grid voltage for the CRT. The grid supply is made separate from the cathode supply so that unblanking pulses may be coupled to the control grid of the cathode-ray tube. The positive end of the control-grid supply is connected to the plate of the unblanking gate amplifier V216B through the INTENSITY control. The negative end is connected to the control grid of the cathode-ray tube. Thus, the entire grid supply follows the unblanking pulse from V216B, transmitting the pulse directly to the control grid of the cathode-ray tube. C3104 transmits the leading edge of the unblanking pulse to reduce unblanking time for fast sweeps.

3-5. SWEEP CIRCUIT (FIGURE 3-2)

a. Sweep Gate Generator

The dc coupled bistable multivibrator, V213A and V213B, initiates the formation of the sweep upon receipt of a negative trigger from the Schmitt Generator at time T_0, and holds off subsequent triggering signals until after the sweep is completed. In the quiescent state, V213A is conducting and V213B is at cutoff. V213A forms a positive gate while V213B forms a negative gate during the forward sweep interval. CR2200 serves as a low-capacitance coupling diode and V212A serves as a high back-impedance diode to couple only negative triggers from the Schmitt Generator to initiate the sweep. After the bistable multivibrator has been triggered, it will revert to its original state at time T_1, by means of a portion of the positive saw supplied from the sweep circuit.

b. Sawtooth Generator

The sawtooth generator is a Miller integrator circuit. The circuit includes the sweep start clamp V214B, the disconnect diode V214C, the Miller integrator V215A, the saw cathode follower V215B, and the RC timing networks mounted on the TIME/CM switch S220. The grid of the saw cathode follower V215B, is connected to the plate of the Miller integrator, V215A, through a neon glow tube E2200. The grid of V215B therefore follows the plate changes of V215A but remains at a fixed negative voltage with respect to the plate.

C2204 and R2237 is a network around E2200 to improve rise time and to suppress parasitic oscillations. At time T_0, the negative step from the sweep gate generator, V213B, to the plate of the disconnect diode, V214C, lowers the plate voltage below the cathode, and this diode no longer conducts.

Consequently, the Miller integrator grid and the plate with its dc coupled saw cathode follower are thus released to seek their own voltage levels.

When the grid of the Miller integrator moves negatively, the plate voltage rises positively, carrying the saw cathode follower grid, cathode, and timing capacitor positively, which thus tends to prevent the Miller integrator grid from going negative. Since the grid of this tube remains at a constant potential within a small fraction of a volt, the current through the TIME/CM charging resistor remains constant, and the sweep timing capacitor thus charges at a constant rate. The linear rise at the cathode of the saw cathode follower is subsequently employed as the internal time base signal.

The cathode of V215B continues to rise linearly until the positive step from the sweep gate generator V213B, at time T_1, returns the disconnect diode V214C back to its conducting state which raises the grid level of the Miller integrator V215A. When V215A grid rises, its plate voltage drops, carrying the saw cathode follower, V215B, with it until its cathode clamps again through V214B and V214C at the quiescent level. The sweep start clamp diode, V214B, holds the start of the sweep constant.

The positive-going transition from the sweep generator, V213B, occurs when a portion of the positive sawtooth is applied to the grid of V213A. This causes the multivibrator to revert to its original state, thereby terminating the sweep. This signal is fed back through the SWEEP LENGTH adjustment, R2222, and the saw turn-off diode V212B. When the voltage tapped off from the SWEEP LENGTH is properly set, the sweep will terminate at a time which corresponds to slightly more than 10 centimeters of deflection at the rate shown on the TIME/CM switch.

The trigger lockout and clamp circuits, V216A and V212C, are designed to hold off any trigger signals from initiating the sweep gate, during the time interval T_1 to T_2, until all capacitances in the circuit have had time to reach their quiescent voltage levels. At time T_3, the sweep gate threshold voltage level is exceeded by the initiating trigger, and the sweep cycle described above is repeated.

4-3. GAINING ACCESS TO CHASSIS

The panels of this instrument are held in place by screws. The bottom mounting holes on each side panel are slotted, eliminating the need for complete removal of screws. To remove panels, loosen the bottom screws and remove the four top screws; then pull the top portion of the panel outward and lift straight up. This will expose most of the tubes and all service adjustments for normal maintenance. To remove bottom panel, lay the instrument on its side, remove the four screws and pull off the panel. Panels are replaced by reversing the order of their removal.

4-4. CATHODE-RAY TUBE REPLACEMENT

CAUTION

THE CATHODE-RAY TUBE SHOULD BE HANDLED WITH CARE TO PREVENT BREAKAGE AND/OR SERIOUS PERSONAL INJURY FROM FLYING GLASS. DO NOT EMPLOY FORCE AT ANY TIME. AS AN ADDED PRECAUTION, IT IS ADVISABLE TO WEAR SAFETY GOGGLES AND GLOVES.

The folowing step-by-step procedure is suggested for replacing the cathode-ray tube:

1) Turn off the power and remove the side panels.
2) Remove bezel held by four screws at front panel.
3) Remove the cathode-ray tube socket and intensifier button.
4) Loosen the clamp screw at the neck of the cathode-ray tube accessible through the side of the cathode-ray tube magnetic shield.
5) Pull the cathode-ray tube straight out through the front panel.
6) Remove rubber sleeve from neck and transfer to new tube.
7) Install new tube through front-panel opening, and replace tube socket, intensifier and bezel.
8) Apply power and check the sweep; if not horizontal, rotate the tube as required using the handle attached to the socket.
9) Tighten the cathode-ray tube neck-clamp screw securely to prevent rotation of the tube.

4-5. ILLUMINATED SCALE LAMP REPLACEMENT

Defective scale lamps are removed as follows:

1. Turn off power and remove side panels.
2. Remove the appropriate lamp assembly located on the rear side of the front panel by squeezing together the spring clip. The defective bulb may then be removed and replaced.

Note: The scale lamps are connected in series-parallel. One defective lamp will cause two to be out at the same time.

4-6. SERVICING HINTS

This is a complex electronic instrument. There is no simple way of locating troubles. An understanding of the functions of the circuits is the best help. With an understanding of the circuits, you will be able to make a reasonable assumption at the general source of troubles from their symptoms.

To keep electronic units operating at top performance, it is desirable to check the equipment at regular intervals. How often it is checked, will depend on the installation and the conditions of operation. In general, portable units moved about constantly will require more frequent service than units fastened down permanently.

For these regular checks, clean all dust and dirt from the unit, using a light air blast or soft brush. Be sure that the dust is removed from around tube socket contacts and terminal strip connections.

In the event of improper equipment performance, the following suggestions are recommended:

1) Note that all tube heaters are lit, or feel tubes for warmth.
2) If the instrument fails to operate, including the pilot light, check the source of power and determine that the power cord is firmly in place. Then check the fuse at the rear of the instrument. A thermal cutout switch is incorporated only in the rack-mounted version of the Type 401-B. If the instrument has been working but has just stopped, it may have overheated and tripped the thermal cutout switch. The thermal cutout switch will reset itself when the interior temperature of the instrument drops to a

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

This section of the manual contains Service Information and Procedures for Internal Adjustments.

WARNING

OBSERVE THE FOLLOWING PRECAUTIONS WHEN NECESSARY TO ENERGIZE THE EQUIPMENT WITH THE PANELS REMOVED

1) Never work alone.
2) Make sure the chassis is properly grounded.
3) Disconnect power cord before changing any tubes.
4) Before touching any components, short the terminals to remove any possible charge that may remain after turning off the power.

4-2. PREVENTIVE MAINTENANCE

You should visually inspect the entire Oscilloscope every few months for possible circuit defects. These defects may include such things as loose or broken connections, damaged binding posts, improperly seated tubes, scorched wires or resistors, missing tube shields, or broken terminal strips. For most visual troubles the remedy is apparent; however, particular care must be taken when heat-damaged components are detected. Overheating of components is often the consequence of other, less obvious defects in the circuit. It is essential that you determine the cause of overheating before replacing heat-damaged components in order to prevent further damage. This Oscilloscope is a stable instrument that will provide many hours of trouble-free operation. However, to insure the reliability of measurements, we suggest that you recalibrate the instruments after each 500 hours of operation (or every six months if used intermittently). Complete recalibration procedures are given in this manual.

Normally, it will not be necessary to make all of the adjustments in the paragraphs to follow. However, any adjustment that is made, should be accomplished in the indicated sequence.

WARNING

WHEN THE PANELS ARE REMOVED FROM THE INSTRUMENT FOR SERVICING, EXERCISE CAUTION WHILE THE POWER IS ON. The lower-voltage busses are potentially more dangerous than the cathode-ray tube potential because of the high-current capabilities and large filter capacitors employed in these supplies. When you reach into the instrument with one hand while it is turned on, do not grasp the metal frame with the other hand. If possible, stand on an insulated floor and use insulated tools. It is advisable to ground the third lead in the power cord whenever the instrument is in use.

4-9. SERVICE ADJUSTMENTS

a. Introduction

The adjustments outlined in the following paragraphs are based on the test procedure followed at the factory.

Normally only periodic adjustment of the CAL and BALance controls will be necessary. The procedure outlined in this manual should be followed. The attenuators are factory aligned and should not be touched unless there is a positive indication that they require adjustment.

All adjustments should be made at mid-line voltage 115V/230V ± 2%.

b. Test Equipment Required
(Equivalent may be substituted)

2	Volt-ohm-meters	—	Simpson Model 260 20,000 ohms/volt sensitivity
1	Square Wave Generator	—	Tektronix Type 105-A
1	Time Calibrator	—	Tektronix Type 180-A
1	Standard Amplitude Calibrator	—	Ballantine Type 420
1	High Voltage Meter	—	Sensitive Research Model DCH-1
1	Autotransformer	—	Powerstat, Variac; capable of varying line voltage of the instrument being calibrated from 103 volts to 127 volts
1	Digital Voltmeter	—	John Fluke Model 800; incremental accuracy of 0.5% or better
1	AC Voltmeter	—	Weston Model 433
1	VTVM	—	Du Mont Type 405 or equivalent

4-10. LOW-VOLTAGE POWER SUPPLY

Two separate voltage adjustments controlled by a stacked potentiometer, R3234F and R, are provided to adjust the +390V and +150V source. The +390V should be adjusted first. Two fixed voltages (—50V and +85V) are also available.

The following adjustments should be checked and readjusted if necessary. Use a John Fluke Model 800 or equivalent DC Voltmeter with an incremental accuracy of ±0.5% or better. Refer to Figures 4-1 through 4-3 and Schematic 98002101-4, Sheet 3, for location of tubes, controls and voltage points. Allow approximately twenty minutes for warmup before making any adjustments.

Preset front-panel controls as follows:

CONTROL	POSITION
X VOLTS/CM	CAL
Y VOLTS/CM	DRIV
TIME/CM	10 MS
TRIG IN	AC
TRIG LEVEL	PRESET
TRIGGER SOURCE	+ INT
VERNIERS (all three)	CAL

a. +85-Volt Supply

There is no adjustment for the + 85 volts. Its source is the Voltage Regulator V323. If this voltage reference tube is inoperative, all the other low-voltage supplies will also be inoperative.

safe value. Possible causes of overheating are: restriction of air circulation and high ambient temperature.

3) If the pilot light operates but there is no spot visible there is a possibility that the spot is positioned off the screen. Check whether the beam-position-indicator lamps are operating and if the Y and X POSITION controls produce any effect. Advance the INTENSITY control and see if there is some unfocused glow on the screen to indicate operation of the CRT circuitry.

4) Localizing the trouble is made easier by use of an oscilloscope to check waveforms. Use a high-impedance Probe while trouble shooting.

5) Replacement of certain tubes may require resetting of one or more service adjustments. Consult Table 4-1. For optimum stability, the new tube should be allowed a warmup time of at least 10 minutes before making any service adjustments.

6) Maintain a high quality of workmanship. Use a clean bench and soldering iron; keep solder joints smooth and bright; do not overheat any component while soldering. Use heat sinks while soldering semi-conductors.

7) When using accessory probes or adapters, be sure the trouble is *not* originating in the accessory, before suspecting the oscilloscope itself.

8) Troubles are usually caused by tube failure and since several of the heaters are connected in series in this equipment, one may replace all suspected tubes at one time and if the trouble is corrected, return the old tubes one-at-a-time until the offending one is discovered or test each tube on a reliable tube checker. Sometimes the aftermath of tube failure yields charred resistors or overstressed capacitors. A visual inspection will usually expose the damaged component requiring replacement.

4-7. REPLACEMENT PARTS

a. Standard Parts

Replacement for all parts used in Type 401-B Oscilloscopes can be purchased directly from Du Mont. However, since most of the components are standard electronic parts, they can generally be obtained locally in less time than is required to obtain them from the factory.

If it is necessary to order a replacement component from the factory, always give the Type Number and Serial Number of the instrument. Before ordering parts for in-warranty replacement or purchasing them for out-of-warranty replacement, be sure to consult the Parts List in this Manual. The Parts List gives the values, tolerances, ratings, and Du Mont part number for all electrical components used in the instrument. This will help to expedite service.

b. Special Parts

In addition to the standard electronic components mentioned in the previous paragraph, some special parts are also used in the assembly of the Type 401-B Oscilloscopes. These parts, such as special resistor values, transformers, etc., are manufactured specially for Du Mont by other companies in accordance with Du Mont specifications. These parts and most mechanical parts should be ordered directly from Du Mont since they are normally difficult or impossible to obtain from other sources. All parts may be obtained either directly from the factory or through the local Du Mont representative.

Since the production of this instrument, some of the parts may have been superseded by improved components. In such cases, the part numbers of these new components will not be listed in your Parts List. However, if you order a part from Du Mont, and it has been superseded by an improved component, the new part will be shipped in place of the part ordered. Your local Du Mont representative has knowledge of these changes and may call you if a change in your purchase order is necessary.

It is the aim of the Du Mont organization to make available the most reliable commercial oscilloscopes within the state of the art and to provide services which will help the user to rapidly restore any Du Mont equipment to its specified performance. Your local Du Mont field representative maintains a limited number of spare parts or the factory may be asked to air ship replacement parts.

4-8. LOCATIONS OF TUBES, SERVICE ADJUSTMENTS, AND TEST POINTS

The location of tubes, service adjustments and test points are shown on the appropriate outline drawings which will be found in the last section of this Manual.

2. Position trace to left and right edge of scale. Check for bowing. If necessary, adjust PATTERN CORRECTION potentiometer R3108 on rear panel for the straightest line.
3. Set the X VOLTS/CM switch to AUTO and the TIME/CM switch to 20 MS/CM. Check top and bottom of pattern for bowing and pin-cushioning. The PATTERN CORRECTION potentiometer should be adjusted to give the straightest line under all conditions.

b. Astigmatism Adjustment

Adjust ASTIG potentiometer R3105 simultaneously with FOCUS control until optimized focusing of the pattern is obtained in both the horizontal and vertical plane. Keep INTENSITY at normal setting.

c. Intensity Limit Adj

1. Preset front-panel controls as follows:

CONTROL	POSITION
TIME/CM	10 MS/CM
X VOLTS/CM	AUTO
Y VOLTS/CM	CAL

2. Adjust X VERNIER control to give 6 cycles of the calibrated signal in the full scale deflection of 10 centimeters.
3. Turn INTENSITY control fully clockwise and Y VOLTS/CM to OFF.
4. Adjust INTENSITY LIMIT potentiometer R3118 from counterclockwise end to the point where the left end of the trace thickens horizontally for approximately 0.5 centimeter.
5. Turn INTENSITY control counterclockwise until the trace is barely visible.

4-13. DC BALANCE ADJUSTMENTS

When the X and Y DC BALance controls are properly adjusted, there will be no horizontal or vertical displacement of the trace with changes in setting of the VERNIER controls. If the trace shifts when VERNIER controls are rotated, the DC BALance controls should be adjusted in the following manner:

> **CAUTION**
>
> To avoid burn damage to cathode-ray tube, the INTENSITY should be reduced or the spot defocused while making these adjustments.

1. Turn X and Y VOLTS/CM and TIME/CM switches to OFF.
2. Set X and Y VERNIER controls fully counterclockwise.
3. Position a dim beam to center of the CRT screen.
4. While rotating Y VERNIER control R1115 right and left throughout its range, adjust the Y BAL control R1111 to recenter the spot. Correct balance is obtained when there is no depositioning of the spot with any setting of the VERNIER control.
5. Repeat step 4 using the X VERNIER, R1215, and X BAL, R1211, controls.
6. Repeat steps 4 and 5 until there is no depositioning of the beam while the VERNIER controls are rotated throughout their range.
7. To avoid selecting tubes for optimum balance, Tube Type 7730 should be used for V110, V111, V120, and V121.

4-14. CALIBRATOR AND AMPLIFIER GAIN ADJUSTMENTS

The X and Y CAL adjustments are provided to normalize the gain of the VOLTS/CM switch setting. To make calibration adjustments, proceed as follows:

1. Set Y VOLTS/CM switch to 0.01 and Y VERNIER control to CAL position.
2. Apply a 50-millivolt output from Voltage Calibrator Ballantine Type 520, or equivalent, to Y INPUT.
3. Adjust Y CAL potentiometer R1117 for 5 centimeters of vertical deflection.
4. Reset the Y VOLTS/CM switch to CAL and adjust + 150V ADJ potentiometer R3234R, until the calibrator signal is exactly 5 centimeters.

   NOTE: Whenever this adjustment is reset, then the adjustment procedure for Sweep Length, Sweep Calibration, and Sweep Expansion Point, must be repeated.

b. +390-Volt Adjust (R3234F)

Connect voltmeter between the + 390-volt output at Pin 3 of V324 and ground. Adjust R3234F potentiometer for a meter reading of + 390 volts.

c. +150-Volt Adjust (R3234R)

This adjustment is necessary to adjust cal signal amplitude.

Connect voltmeter between the + 150-volt output at Pin 9 of V320 and ground.

NOTE: If meter reading is between 147 and 153 volts positive, do not adjust unless required to in step 4, paragraph 4-14. If outside the above limits, adjust R3234R potentiometer for a preliminary meter reading of + 150 volts. Make final adjustment as indicated in paragraph 4-14, step 4.

d. —50-Volt Supply

There is no adjustment for the — 50-volt supply. Connect voltmeter between the — 50-volt output at the negative terminal of C3300 and ground. The meter should indicate from 48 to 52 volts negative. If this reading is incorrect, trouble shooting is required.

4-11. DEFLECTION PLATE LEVEL ADJUST

The X and Y Deflection Plate Level adjustments are provided to equalize the deflection plate voltage of the cathode-ray tube for optimum spot shape. In addition, the Y DP LEVEL control is adjusted for zero volts dc at the sync take-off junction with spot centered on screen.

To make deflection plate level adjustments, proceed as follows:

a. Y DP Level Adj (R1122)

1. Set controls as indicated to obtain a dim spot on screen.

CONTROL	POSITION
X and Y VOLTS/CM	OFF
TIME/CM	OFF
X and Y VERNIER	Fully cw

2. Center beam with POSITION controls.
3. Connect Simpson 260 Multimeter set to 2.5V range between junction of sync take-off resistors (R1131 and R1132) and ground. See Figure 4-3.
4. Set DP LEVEL ADJ (R1121) for zero volts on meter. Keep beam positioned at center of screen while adjusting DP LEVEL ADJ control. Beam must rest at center of screen when meter reads zero.

b. X DP Level Adj (R1221)

1. With spot on screen, center beam with POSITION controls.
2. Remove deflection plate board cover at rear of unit.
3. Short Y Deflection Plate terminals.
4. Connect two multimeters (Simpson 260 on 250V range), one from each X Deflection Plate terminal to the now common Y Deflection Plate terminal.
5. Keeping the trace centered with the X POSITION control, adjust the X DP LEVEL potentiometer R1221 for minimum equal but opposite polarity reading on meters (less than 10 volts).
6. Increase meter sensitivity (from 250V to 10V range) to obtain more accurate readings.
7. With spot centered, final readings must be equal and less than 10 volts, with one meter reading positive, and one negative.
8. Disconnect meter and Y Deflection Plate short.

4-12. CRT POTENTIAL ADJUSTMENTS

a. Pattern Correction Adjustment

The PATTERN CORRECTION control is provided to optimize the CRT geometry for the left and right edges of the display. Refer to Figure 2-15 when making the following adjustments.

1. Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	CAL
Y VERNIER	5 cm of vertical deflection
X VOLTS/CM	OFF
TIME/CM	OFF
TRIGGER SOURCE	+ INT
TRIG LEVEL	PRESET

b. X Attenuator Adjustments

1. Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	0.1
Y VERNIER	As required
X VOLTS/CM	0.1
TRIG IN	AC
TIME/CM	500 μsec
TIME/CM VERNIER	CAL
TRIGGER SOURCE	— EXT
TRIG LEVEL	PRESET

2. Connect a lead from the Square Wave Generator to the TRIG IN terminals of the Type 401-B for external sync.
3. Connect a clip lead from saw take-off junction to Y INPUT (see Figure 4-3). This applies the sawtooth waveform to amplifier. Adjust for proper sweep.
4. Refer to the preceding paragraph 4-16a and repeat steps 4 and 5 except that trimmers C1203 through C1205 are adjusted for the X attenuator.
5. When all trimmers in both X and Y attenuators have been adjusted, disconnect the generator and clip lead.

4-17. TRIGGER LEVEL CENTERING ADJUSTMENT

The Trigger Level Centering adjustment determines at what voltage on the input triggering waveform, the horizontal trace will start. To make adjustment, proceed as follows:

1. Preset front-panel controls as follows:

CONTROL	POSITION
TRIGGER SOURCE	EXT/10
TRIG LEVEL	PRESET
X VOLTS/CM	DRIV

2. Clip a 620K-ohm resistor from pin 6 of V210 to ground.
3. Connect a Simpson 260 Multimeter, set on 250V dc range, from pin 1 of V211 and ground. Refer to Figure 4-3.
4. Adjust TRIG LEVEL CENT potentiometer R2113 starting from fully clockwise and rotating counterclockwise to a point where meter just indicates a positive shift.
5. When adjustment has been completed, disconnect voltmeter and resistor.

4-18. SWEEP LENGTH ADJUSTMENT

Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	CAL
TIME/CM	10 MS/CM
TIME/CM VERNIER	CAL
X VOLTS/CM	DRIV
Y VERNIER	CAL
TRIGGER SOURCE	+ INT

Adjust X VERNIER control so that both ends of sweep are on screen.

Adjust SWEEP LENGTH potentiometer R2222 for 6¼ cycles of sweep. (60 cps line.)

4-19. SWEEP CALIBRATION ADJUSTMENTS

The Sweep Calibration adjustments are provided to standardize accurately the steps of the TIME/CM switch.

1. Set X VERNIER and TIME/CM VERNIER controls to CAL.
2. Connect Sweep Calibrator, Tektronix Type 180A to Y INPUT.
3. Set TIME/CM switch to the following settings and adjust designated controls and generator for the required pattern.

TIME/CM SETTING	ADJUST CONTROL	GENERATOR SETTING
10 msec	SWP CAL (R2245R)	10 kμs — 1 mark/cm
5 μsec	5 μs CAL (C2211)	1 μs — 5 marks/cm
100 μsec	100 μs CAL (R2225)	100 μs — 1 mark/cm

4. Disconnect sweep calibrator.

4-20. SWEEP EXPANSION POINT ADJUSTMENTS

1. Set up oscilloscope for normal operation with TIME/CM switch at 10 msec.

5. Turn Y VOLTS/CM switch to OFF and disconnect voltage calibrator.
6. Set X VOLTS/CM switch and VERNIER control to CAL.
7. Adjust X CAL potentiometer R1217 for 5 centimeters of horizontal deflection.

4-15. PHASE SHIFT ADJUSTMENT

A phase shift trimmer capacitor C1219 is added across the output of the horizontal deflection amplifier to adjust for zero phase differential between the X and Y amplifier at 200 Kc. To make phase shift adjustment at 200 Kc, proceed as follows:

> **NOTE**
>
> This adjustment need not be performed unless C1219 is readjusted while normalizing phase at a particular frequency during day-to-day use of the 401-B.

1. Set X and Y VOLTS/CM switches to 0.01.
2. Set X and Y VERNIER controls for maximum gain.
3. Apply 200 Kc sine wave to both the X and Y INPUTS.
4. Adjust output of generator to obtain 10 centimeters of vertical deflection.
5. Adjust PHASE SHIFT ADJ, trimmer capacitor C1219 for a closed pattern on the screen.

4-16. ATTENUATOR ADJUSTMENTS

The attenuators are factory aligned and should not be touched unless there is a positive indication that they require adjustment. If adjustment is necessary, follow the steps as outlined below.

a. Y Attenuator Adjustments

1. Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	.01
Y VERNIER	CAL
X VOLTS/CM	DRIV
X VERNIER	CAL
TRIGGER SOURCE	INT
TRIG LEVEL	PRESET
TRIG IN	AC
TIME/CM	500 μsec

2. Connect a Tektronix Type 105 Square Wave Generator to Y INPUT.
3. Set the Generator to 1 Kc and adjust its symmetry and output amplitude control to obtain a symmetrical square-wave on the screen. Observe any excess peaking on the square wave. This peaking is in the generator (Tektronix Type 105) and all succeeding adjustments must give the same waveform distortion as seen on the .01 VOLTS/CM range.
4. Set the Y VOLTS/CM switch to 0.1 and adjust the output of the generator for no more than 4 centimeters of vertical deflection. Adjust the fully clockwise trimmer C1103 for flat top on the square wave.
5. Advance in the counterclockwise direction one trimmer at a time with each setting of the Y VOLTS/CM switch, adjusting trimmers C1104 and C1105 for a flat pulse response as shown in Figure 4-0, B, below. Figures A and C show incorrect waveform.

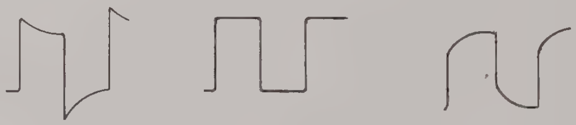


Figure 4-0. Waveforms Encountered when Adjusting Attenuator

6. When all trimmers in the Y Circuit have been adjusted, reconnect generator to the X INPUT.

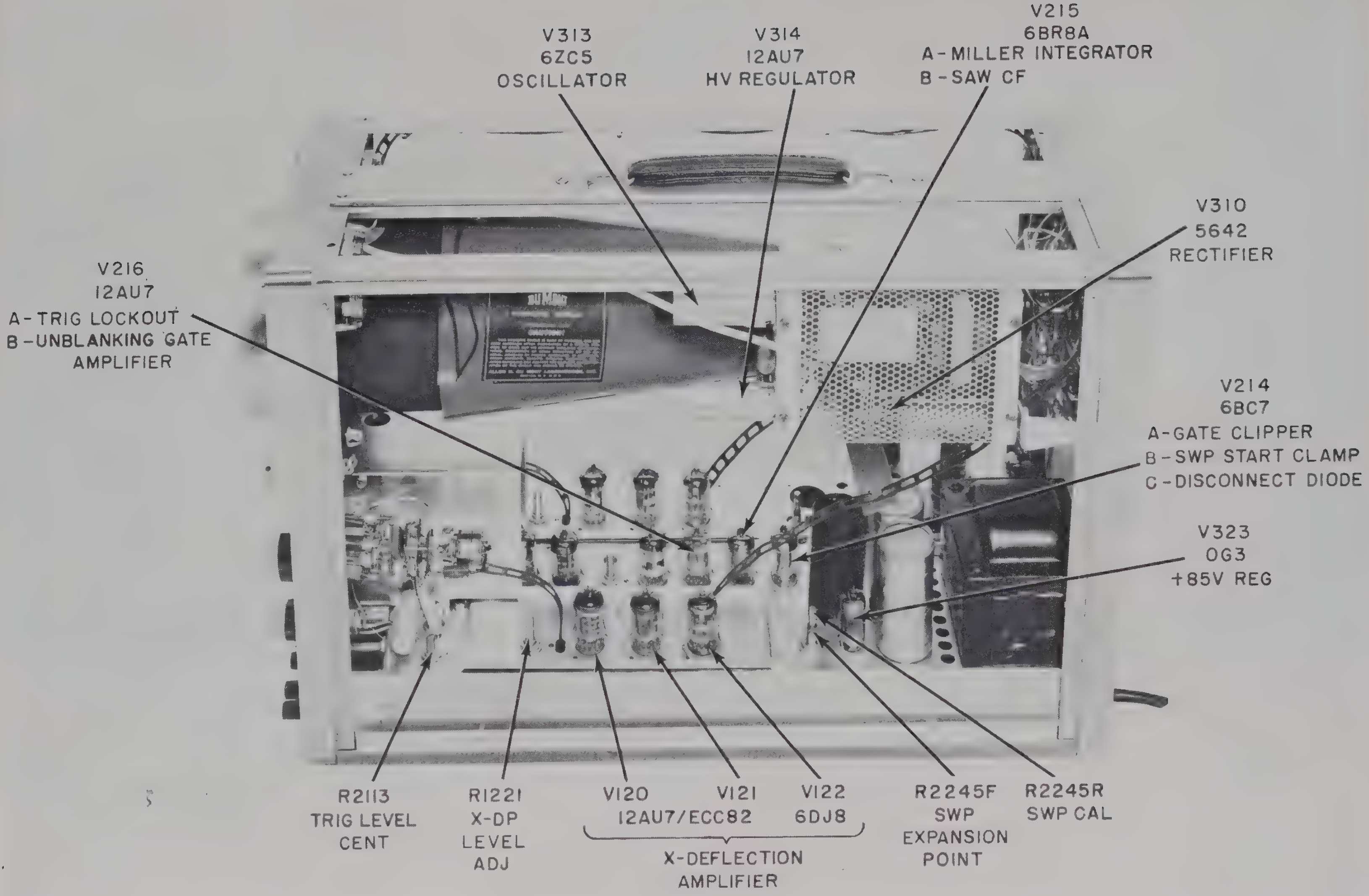


Figure 4-1. Tube Location & Service Adjustments, (Right Side)

2. Check that X BALance is properly adjusted; see paragraph 4-13.
3. Rotate X VERNIER fully counterclockwise. Position trace so it is centered vertically on the screen.
4. Rotate X VERNIER control clockwise and check that trace expands equally from center to outside edges.
5. If adjustment is necessary, adjust SWEEP EXPANSION POINT potentiometer R2245F while rotating X VERNIER control R1215 until trace expands equally from center to outside edges.

TABLE 4-1

ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

CONTROL NUMBER	SERVICE ADJUSTMENT	REF.	CONTROL NUMBER	SERVICE ADJUSTMENT	REF.
1	Y Bal	R1111	9	Sweep Length	R2222
2	X Bal	R1211	10	Sweep Expansion Point	R2245F
3	Y Cal	R1117	11	Sweep Cal	R2245R
4	X Cal	R1217	12	+ 390V	R3234F
5	Y DP Level	R1121	13	+ 150V	R3234R
6	X DP Level	R1221	14	Astigmatism	R3105
7	Phase Shift	C1219	15	Pattern Correction	R3108
8	Trig Level Centering	R2113	16	Intensity Limit	R3118

SYMBOL	TUBE TYPE	ADJUST CONTROL NUMBER
* V110	ECC82/12AU7	1, 3, 5, 7
* V111, V112	ECC82/12AU7, 6DJ8	3, 5, 7
* V120	ECC82/12AU7	2, 4, 6, 7
* V121, V122	ECC82/12AU7, 6DJ8	4, 6, 7
V210, V211	6DJ8	8
V212	6BC7	None
V213	12AU7	9
V214	6BC7	None
V215	6BR8A	9, 10, 11
V216	12AU7	None
V310	5642	None
V313	6CZ5	None
V314	12AU7	None
V315	K1931	3, 4, 14, 15, 16
V320	6BJ8	9, 10, 11, 13 (See Para. 4-14, step 4)
V321	5AR4/GZ34	None
V322	6BR8A	Complete Recalibration
V323	OG3	Complete Recalibration
V324	6AS7G	Complete Recalibration
V325	6BR8A	1, 2, 5, 6, 11

* To avoid selecting tubes for optimum balance, Tube Type 7730 should be used for V110, V111, V120, and V121

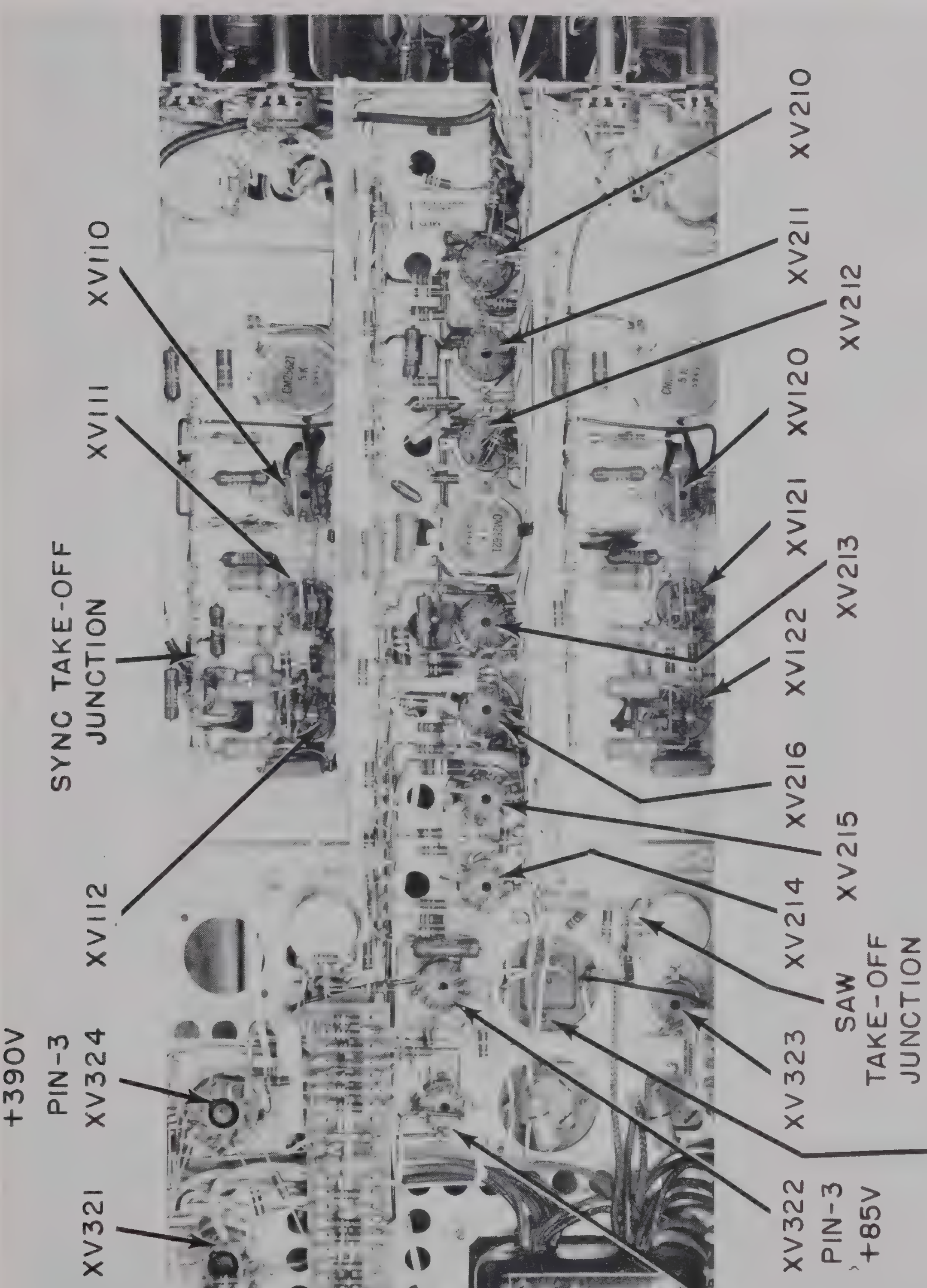


Figure 4-3. Tube Sockets & Sync Take-Off Location, (Bottom View)

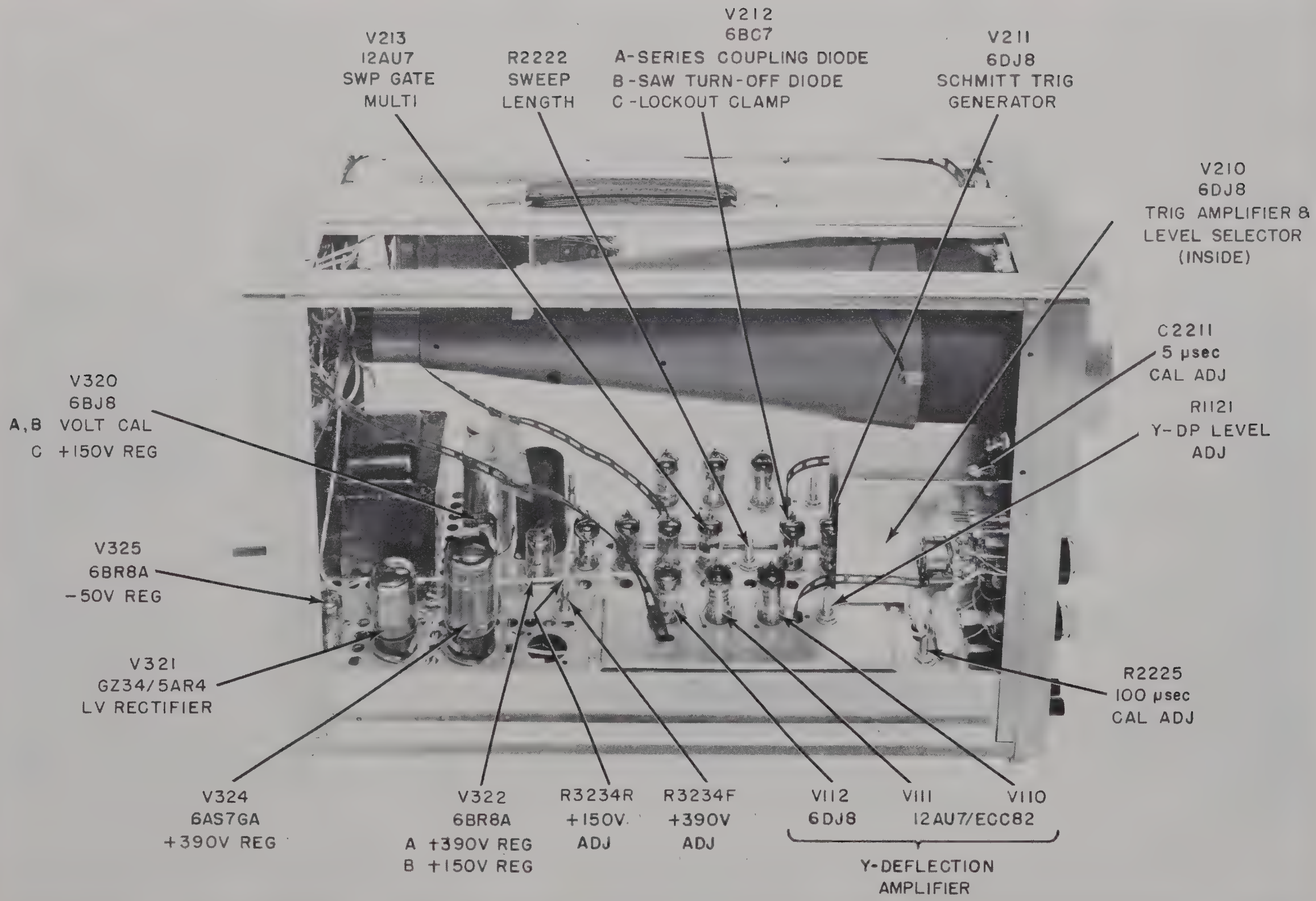


Figure 4-2. Tube Location & Service Adjustments, (Left Side)

5-3. CHECKING THE VERTICAL AND HORIZONTAL DEFLECTION AMPLIFIERS

a. DC Balance Adjustment

1. Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	OFF
Y VERNIER	Fully ccw
TIME/CM	OFF
X VOLTS/CM	OFF
X VERNIER	Fully ccw
X and Y POSITION	Center the spot

CAUTION

Reduce INTENSITY setting or defocus spot slightly to avoid damaging the cathode-ray tube screen.

2. Rotate the Y VERNIER control fully clockwise and return beam to center of screen with the front-panel screwdriver Y BAL control.
3. Repeat several times until the spot does not move when the Y VERNIER control is rotated.
4. Repeat the above procedure for balancing the X Channel.

b. Y CAL Adjustment

1. Turn Y VOLTS/CM and Y VERNIER controls to CAL.
2. Position the ends of the trace to the two CAL marks ± 2½ cm from the center of the screen.
3. If the ends of the trace do not coincide with the marks on the scale, adjust the Y CAL control until they do. Be careful to avoid parallax errors when making this adjustment.
4. Repeat the above procedure for the X Channel.

c. Calibrate Signal Amplitude Check

1. Turn the Y VOLTS/CM switch to .01.
2. Apply a 50-millivolt peak-to-peak 1 Kc sine wave from a Ballantine Type 420 Calibrator or equivalent ± ½% accurate source to the Y INPUT.
3. The length of the trace measured between the CAL marks should be 4.9 to 5.1 centimeters. If this requirement is not met, refer to the paragraph entitled "Calibrator and Amplifier Gain Adjustments" in Section 4 of this Instruction Manual.

5-4. CHECKING THE SWEEP

a. Sweep Length Adjustment

Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	CAL
Y VERNIER	CAL
TIME/CM	10 MS/CM
(TIME/CM) VERNIER	CAL
X VOLTS/CM	DRIV
TRIGGER SOURCE	+ INT
X VERNIER	Adjusted so that both ends of the sweep can be observed

Check that between 6 and 6½ cycles of the calibrator signal (60-cycle line) are displayed on the screen. If less than 6 cycles appear, refer to Section 4 of this Instruction Manual for the SWEEP LENGTH adjustment procedure.

b. Sweep CAL Adjustment

Set the X VERNIER control to CAL and check that six cycles of the calibrator waveform (60-cycle line) occupy 9.5 to 10.5 centimeters of the horizontal scan. Exercise care to avoid parallax errors when making this measurement. If this specification is not met, remove the right-side cover and set SWEEP CAL adjustment for 6 cycles of the calibrator waveform in 10 centimeters.

c. Trigger Level Control Check

Turn the TRIG LEVEL control clockwise out of PRESET position; the trace should disappear. Rotation of this control should allow selection of this level on the positive slope of the waveform at which the sweep starts. Return TRIG LEVEL control to PRESET.

SECTION V

PERFORMANCE ASSURANCE TEST

5-1. MAINTENANCE CHECK TO ASSURE PERFORMANCE

The tests described in the paragraphs to follow should be performed by Instrument Test Departments and Maintenance Laboratories to certify proper performance of the Type 401-B Oscilloscope. These tests are divided into sections for simplification and to assist those test groups where complete checking is not mandatory, or where all test equipment is not available.

NOTE

If this oscilloscope is checked by a receiving inspection laboratory, the tests outlined below are recommended to certify performance. The Type 401-B Oscilloscope has been thoroughly tested and aged at the factory. Nevertheless, rough shipment, extreme environments, or long idle periods may necessitate minor adjustments of the controls. Hence, it is suggested that the certifying engineer try the recommended adjustments not only for recentering the controls, but also to ascertain their range and to familiarize himself with this precision instrument. If, after performing all the tests outlined below, the instrument will not perform to specification, the assistance of the local Du Mont Field Engineering Representative should be requested.

5-2. CHECKING THE POWER SUPPLY

1. Check fuses for proper value.
2. Examine the instrument for charred or mechanically damaged components, loose connectors and improperly seated tubes; correct all defects.
3. Apply power to the Type 401-B Oscilloscope through a variable voltage source (Variac, or an equivalent). Set the line voltage to 115 volts. (Double this value for 230-volt operation.)
4. Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	CAL
X VOLTS/CM	DRIV
VERNIERS (all three)	CAL
TIME/CM	10 MS
TRIG IN	AC
TRIG LEVEL	PRESET
TRIGGER SOURCE	+ INT

   Six cycles of the calibrator signal should be displayed on the screen.

5. Allow 20 minutes for warmup before making any adjustments.
6. Lower the line voltage until the display starts to drift, or becomes erratic. The line voltage must be less than 103.5 volts at 60 cycles (207 volts for 230-volt operation). If instability is noted before the lower limit of the line voltage is reached, check operation of the low voltage power supplies as outlined in Section 4 of this Instruction Manual.
7. Raise the line voltage to 126.5 volts (253 volts for 230-volt operation). The display should remain stable and must not be erratic. If instability is noted before the upper limit of the line voltage is reached, check operation of the low-voltage power supplies.
8. Reset the line voltage to 115 volts (230 volts for 230-volt operation).

HANDLES, RACK
6401 2472

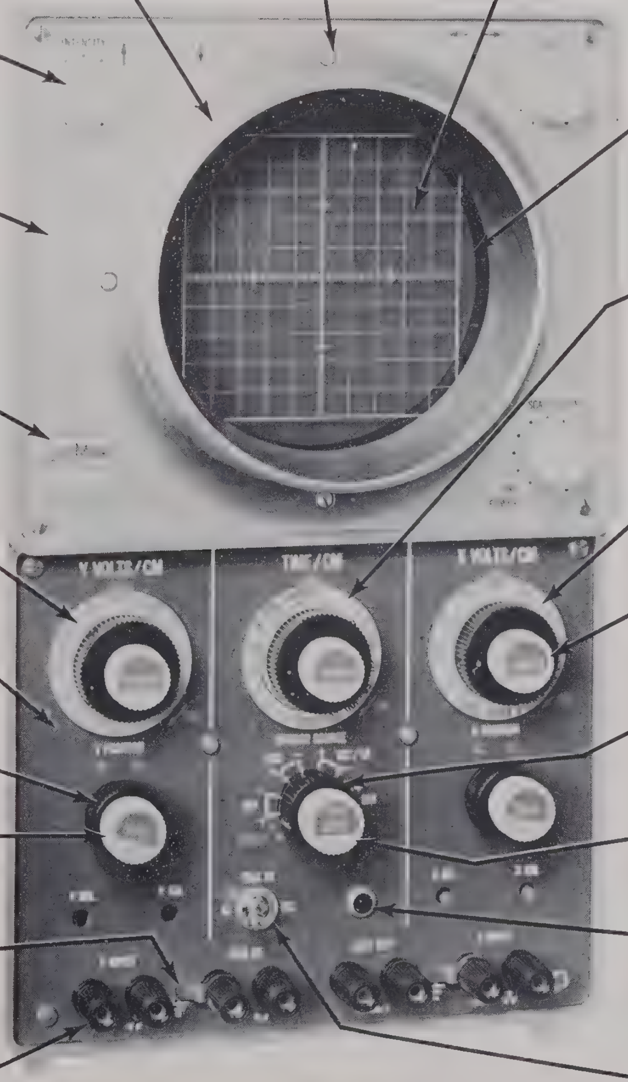
PANEL FRONT, RACK:
3200 9671

ACCESSORIES:

PROBE:
Type 4290

CONNECTOR:
G–R 9800 0629

SWEEP REARMING KIT:
Type 4001



HANDLE, CARRYING:
6400 3730

BEZEL:
6401 2092

SCREWS:
6008 1460
6-32x1/2

SCALE:
4500 8683

KNOBS:
Intensity, Focus, Power
4500 8923

PANEL UPPER:
3200 9631

DECAL:
6703 7921

KNOB ASSY:
Y VOLTS/CM
8700 1132

PANEL LOWER:
3200 9641

KNOBS:
Position
4500 8974

KNOBS:
Input
4500 9953

LINKS:
0903 1051

BINDING POSTS:
5101 2551

FILTERS:
4800 4511 – Green
4800 4512 – Blue
4800 4513 – Amber

KNOB ASSY:
Time/Cm
8700 1133

KNOB ASSY:
X Volts/Cm
8700 1131

KNOBS:
Vernier
4500 9951

KNOB:
Trigger Source
4500 8945

KNOB:
Trig Level
4500 9952

PILOT LIGHT:
1201 1770

SWITCH:
Trig (AC/DC)
0500 2000

Figure 6-0. Identification of Replaceable Parts

d. DC Coupled Trigger Check

Set TRIG IN switch to DC. Position the pattern vertically across the face of the tube. The point on the scale at which the pattern starts should remain constant. The pattern should disappear when it no longer crosses the trigger point. Return the TRIG IN switch to AC.

e. Trigger Polarity Check

Turn the TRIGGER SOURCE switch to — INT. Check that the sweep now starts on the negative slope of the waveform. Set the TRIGGER SOURCE switch to + LINE. The pattern should remain in sync.

f. Auto Triggering Check

Turn the TRIGGER SOURCE switch to + EXT/10. No sweep should be visible. Turn the X VOLTS/CM switch to AUTO. The display should be visible but out of sync. Return the TRIGGER SOURCE switch to — LINE. The pattern should now be in sync.

g. Checking Single Sweep

1. Turn the X VOLTS/CM switch to SINGLE. The trace should disappear and the Reset Indicator lamp should be lit.
2. Turn the TRIGGER SOURCE switch to + EXT/10 and then the X VOLTS/CM switch to RESET. The Reset Indicator lamp should go out.
3. Return TRIGGER SOURCE switch to — LINE. Only one trace should appear. The Reset Indicator lamp will now be lit.
4. Return X VOLTS/CM switch to SINGLE and repeat sequence several times with various sweep rates. Only one sweep should appear as the TRIGGER SOURCE switch is operated.

   NOTE: If trigger signals are available as the X VOLTS/CM switch is turned from SINGLE to RESET; the sweep will fire immediately. If the sweep speed is high, a viewing hood may be necessary to see the single stroke of the time base.

5-5. CHECKING FREQUENCY RESPONSE OF X AND Y AMPLIFIERS

a. Y Amplifier

1. Preset front-panel controls as follows:

CONTROL	POSITION
Y VOLTS/CM	.01
Y VERNIER	CAL
TIME/CM	OFF
X VOLTS/CM	OFF

2. Connect a Test Oscillator, Hewlett Packard or equivalent, to the Y INPUT.

   NOTE: Be sure that the Type 650A is properly terminated in 600 ohms.

3. Set the generator output for approximately 0.035 volts rms, and at a sine wave frequency of 1 Kc.
4. Adjust the generator for exactly 10 centimeters of vertical deflection. Avoid parallax errors when making this adjustment.
5. Note the exact reading of the Voltmeter on the Test Oscillator.
6. Change the frequency to 500 Kc and readjust the Test Oscillator to the same reading. The trace must now displace no less than 6.3 centimeters of vertical deflection.

b. X Amplifier

1. Preset front-panel controls as follows:

CONTROL	POSITION
X VOLTS/CM	.01
X VERNIER	CAL
TIME/CM	OFF
Y VOLTS/CM	OFF

2. Connect the Test Oscillator to the X INPUT.
3. Repeat steps 3 through 6 of paragraph 5-5a using X-circuit nomenclature and control.

section 6
electrical parts list and schematics

SYMBOL	PART NUMBER	DESCRIPTION
C3213	0326 4640	0.01 µf, GMV
C3214	0318 4340	plastic, 0.1 µf, ±20%, 600V
C3215	0326 2270	electrolytic, 10 µf, +50 −10%, 450V
C3216	0326 4640	0.01 µf, GMV
C3217	0315 7500	electrolytic, 10 µf, 250V
	CAPACITORS (3300)	
C3300	0314 3430	electrolytic, 150 µf, 200V
C3301 to C3303	0326 4640	0.01 µf, GMV
C3304	0301 3300	electrolytic, 20 µf, 150V
	CAPACITORS (3400)	
C3401 & C3402	0326 4660	0.02 µf, GMV
	SEMICONDUCTORS	
CR2200	2600 1530	germanium, 50 ma dc, 1N34A
CR3101 & CR3102	2600 6620	diode, selenium
CR3300 & CR3301	2600 6370	diode, silicon, 1N1169
CR3300 & CR3301	2600 6670	diode, 1N1763 (Alternate)
	LAMPS	
DS1101 & DS1102	1201 1900	indicator, neon, NE-2A, ¼W
DS1201 & DS1202	1201 1900	indicator, neon, NE-2A, ¼W
DS3400	1201 1280	incandescent, miniature, 2-pin, 150 ma, 6.3V, GE #12
DS3401 to DS3404	1201 0960	incandescent, miniature, bayonet, 0.16 ampere, 3.2V, #1490
	LAMP	
E2200	1200 3960	glow, NE-2, 0.3 ma, 1/25W
	FUSES	
F3200	1100 5210	3 amperes, slow-blow, 115-volt operation
F3200	1100 5270	1.5 amperes, slow-blow, 230-volt operation
	ELECTRICAL CONNECTORS	
	Bench and Rack Models, Front Panel	
J1101 to J1103	5101 2551	Binding Post (Y INPUT)
J1201 to 1203	5101 2551	Binding Post (X INPUT)
J2100	5101 2551	Binding Post (TRIG IN)
J2200	5101 2551	Binding Post (GATE OUT)
	Rack Model only, Rear Panel	
J4100	5101 2551	Binding Post (TRIG IN)
J4101 to J4103	5101 2551	Binding Post (Y INPUT)
J4200	5101 2551	Binding Post (GATE OUT)
J4201 to J4203	5101 2551	Binding Post (X INPUT)
	Bench and Rack Models	
P3100	0904 3841	plug, high voltage

RESISTORS (1100)

Notes: 1. All resistors are fixed, composition, ±5%, and ½W unless otherwise specified.

2. Resistance values in ohms: K = thousand
M = million

SYMBOL	PART NUMBER	DESCRIPTION
R1101	0229 6290	film, 1M, ±1%
R1102	0229 5240	film, 124K, ±1%
R1103	0229 5230	film, 10.2K, ±1%
R1104	0239 0764	film, 1K, ±1%
R1105 & R1106	0229 4990	film, 1M, ±1%
R1107 & R1108	0203 2050	220K, ±10%
R1109	0239 0364	film, 15K, ±1%
R1110	0204 1430	9.1M
R1111	0108 6010	variable, 250 (Y BAL)
R1112 & R1113	0239 0419	film, 16.5K, ±1%
R1114	0203 0410	510
R1115	0107 2332	variable, 100K (Y VERNIER)
R1116	0203 0620	3900
R1117	0108 6110	variable, 50K, 1/3W (Y CAL)
R1118	0203 0410	510
R1119	0203 3640	4700, 1W
R1120	0203 0440	680
R1121	0102 1440	variable, wire wound, 5K, 2W (Y-DP LEVEL ADJ)
R1122	0107 2321	variable, 500 (Y POSITION)
R1123 & R1124	0239 1417	film, 62K, 2W
R1125 & R1126	0203 1630	68, ±10%
R1127	0234 5100	wire wound, 12K, 3W
R1128 & R1129	0234 4800	wire wound, 25K, 3W
R1131	0239 0841	film, 750K, ±1%
R1132	0229 5190	film, 3.65M, ±1%
R1133	0203 2070	330K, ±10%
R1134 & R1135	0203 2050	220K, ±10%
R1136	0203 2070	330K, ±10%
R1138	0203 2010	100K, ±10%
R1141	0203 0440	680
	RESISTORS (1200)	
R1201	0229 6290	film, 1M, ±1%
R1202	0229 5240	film, 124K, ±1%
R1203	0229 5230	film, 10.2K, ±1%
R1204	0239 0764	film, 1K, ±1%
R1205 & R1206	0229 4990	film, 1M, ±1%
R1207 & R1208	0203 2050	220K, ±10%
R1209	0239 0364	film, 15K, ±1%
R1210	0204 1430	9.1M
R1211	0108 6010	variable, 250 (X BAL)
R1212 & R1213	0239 0419	film, 16.5K, ±1%
R1214	0203 0410	510
R1215	0107 2332	variable, 100K (X VERNIER)
R1216	0203 0620	3900
R1217	0108 6110	variable, 50K, 1/3W (X CAL)
R1218	0203 0410	510
R1219	0203 3640	4700, 1W
R1220	0203 0440	680

SECTION VI

ELECTRICAL PARTS LIST AND SCHEMATICS

CAPACITORS (1100)

Notes: 1. All capacitors are fixed, ceramic, ±10%, and 500V unless otherwise specified.

2. GMV denotes Guaranteed Minimum Value.

SYMBOL	PART NUMBER	DESCRIPTION
C1101	0319 7760	Plastic, 0.1 μf, 600V
C1102	0305 5020	Mica, 24 μμf, ±5%
C1103 to C1105	0316 9631	variable, glass, 1-12 μμf, 600V
C1106	0305 5780	mica, 270 μμf
C1107	0302 0560	mica, 820 μμf
C1108	0303 3650	mica, 8200 μμf, 300V
C1109	0326 4640	0.01 μf, GMV
C1110	0305 5000	mica, 20 μμf, ±5%
C1111	0326 4640	0.01 μf, GMV
C1113 & C1114	0313 3900	composition, 3.3 μμf
C1115 & C1116	0313 3870	composition, 2.2 μμf
C1117	0305 5000	mica, 20 μμf, ±5%
C1118	0302 0320	mica, 12 μμf
C1119	0313 3960	composition, 10 μμf
C1122 & C1123	0313 3870	composition, 2.2 μμf

CAPACITORS (1200)

SYMBOL	PART NUMBER	DESCRIPTION
C1201	0319 7760	plastic, 0.1 μf, 600V
C1202	0305 5020	mica, 24 μμf, ±5%
C1203 to C1205	0316 9631	variable, glass, 1-12 μμf, 600V
C1206	0305 5780	mica, 270 μμf
C1207	0302 0560	mica, 820 μμf
C1208	0303 3650	mica, 8200 μμf
C1209	0326 4640	0.01 μf, GMV
C1210	0305 5000	mica, 20 μμf, ±5%
C1211	0326 4640	0.01 μf, GMV
C1213 & C1214	0313 3900	composition 3.3 μμf
C1215 & C1216	0313 3870	composition, 2.2 μμf
C1217	0305 5000	mica, 20 μμf, ±5%
C1219	0319 6880	variable, 1.5-7 μμf, 350V
C1220	0319 0310	0.04 μf, GMV, 600V

CAPACITORS (2100)

SYMBOL	PART NUMBER	DESCRIPTION
C2100	0305 5580	mica, 39 μμf
C2102	0313 3920	composition, 4.7 μμf
C2103	0326 4520	1000 μμf, GMV
C2104	0326 4560	0.0022 μf, GMV
C2105	0326 4640	0.01 μf, GMV
C2106	0305 5600	mica, 47 μμf
C2107	0326 4520	1000 μμf, GMV
C2108	0318 4450	plastic, 0.033 μf, ±5%, 150V
C2110	0326 4640	0.01 μf, GMV
C2111	0305 5580	mica, 39 μμf

CAPACITORS (2200)

SYMBOL	PART NUMBER	DESCRIPTION
C2200	0305 5120	mica, 62 μμf, ±5%
C2201 & C2202	0305 5520	mica, 22 μμf
C2203	0305 5820	mica, 390 μμf
C2204	0317 4800	0.01 μf, ±20%
C2205	0326 4660	0.02 μf, GMV
C2206	0318 0250	plastic, 0.47 μf, ±20%, 150V
C2207	0313 5260	mica, 470 μμf, ±20%, 300V
C2208	0313 3910	composition, 3.9 μμf
C2211	0315 0530	variable, 8-50 μμf, 350V
C2212	0305 5160	mica, 91 μμf, ±5%
C2213	0319 7060	plastic, 0.12 μf, ±20%, 200V
C2214	0302 2000	mica, 910 μμf, ±5%, 300V
C2215	0303 0140	mica, 4700 μμf, ±5%
C2216	0305 5520	mica, 22 μμf
C2217	0318 4400	plastic, 0.015 μf, ±5%, 150V

CAPACITORS (3100)

SYMBOL	PART NUMBER	DESCRIPTION
C3100 & C3101	0316 9080	470 μμf, ±20%, 4000V
C3102 to C3107	0316 4930	0.01 μf, +100 —0%, 2000V
C3108	0316 8650	22 μμf, 2000V
C3109	0319 3200	paper, 0.1 μf, 600V
C3110	0305 5100	mica, 51 μμf, ±5%
C3111	0317 3900	1000 μμf
C3112 & C3113	0303 8580	mica, 510 μμf, 1000V
C3114	0319 3200	paper, 0.1 μf, 600V
C3115	0316 4930	0.01 μf, +100 —0%, 2000V
C3116	0302 1140	mica, 510 μμf, ±5%
C3117	0316 4930	0.01 μf, 2000V
C3121	0305 5030	mica, 27 μμf, ±5%
C3122	0305 5110	mica, 56 μμf, ±5%

CAPACITORS (3200)

SYMBOL	PART NUMBER	DESCRIPTION
C3200	0326 4640	0.01 μf, GMV
C3203	0326 4520	1000 μμf, GMV
C3211 & C3212	0319 4480	125 μf, +100 —10%, 350V

SYMBOL	PART NUMBER	DESCRIPTION
R3111	0211 2260	wire wound, 2K, ±10%
R3112	0203 2010	100K, ±10%
R3113	0203 1890	10K, ±10%
R3114 & R3115	0203 2090	470K, ±10%
R3116	0234 2640	film, 36K, ±10%, 5W
R3117	0203 1440	10M
R3118	0108 6200	variable, 1M (INTENSITY LIMIT)
R3119	0108 6300	variable, 500K (INTENSITY)
R3120	0203 2010	100K, ±10%
R3121 & R3122	0203 4300	2.7M, 1W
R3123	0203 1770	1K, ±10%
R3124	0203 1030	200K
R3125	0203 1610	47, ±10%

RESISTORS (3200)

SYMBOL	PART NUMBER	DESCRIPTION
R3200	0239 1501	film, 560K, ±10%, 2W
R3201	0203 2130	1M, ±10%
R3202	0203 1930	22K, ±10%
R3203	0229 6140	film, 2M, ±1%
R3205	0229 5060	film, 665, ±1%
R3207	0203 1000	150K
R3210	0203 2130	1M, ±10%
R3220	0203 1940	2700, ±10%
R3221 & R3222	0239 1491	film, 100K, ±10%, 2W
R3223	0203 1170	750K
R3224	0203 2080	390K, ±10%
R3225	0203 0950	91K
R3227	0203 3770	16K, 1W
R3228	0228 7430	wire wound, 3500, ±10%, 20W
R3229	0203 1730	470, ±10%
R3230	0203 1590	33, ±10%
R3231	0203 2130	1M, ±10%
R3232	0239 1406	film, 24K, 2W
R3233	0203 1250	1.6M
R3234 F, R	0108 6650	variable, 1M/1M, (+390V ADJ, +150V ADJ)
R3235	0203 1160	680K
R3236	0203 1030	200K
R3237	0234 2640	film, 36K, ±10%, 5W
R3240	0239 1384	film, 3600, 2W
R3241	0203 2090	470K, ±10%
R3242	0203 1510	20M
R3243 & R3244	0203 1730	470, ±10%
R3245	0203 1010	160K
R3246	0203 1080	330K
R3247	0203 0880	47K
R3248	0203 0790	20K
R3249	0203 3860	39K, 1W

RESISTORS (3300)

SYMBOL	PART NUMBER	DESCRIPTION
R3300	0229 5250	film, 182K, ±1%
R3301	0229 7310	film, 100K, ±1%
R3302	0203 0960	100K
R3303	0203 0910	62K
R3304	0203 1730	470, ±10%
R3305	0203 1150	620K
R3306	0203 1170	750K
R3307	0203 1060	270K
R3308	0203 1150	620K
R3309	0203 1730	470, ±10%
R3310	0203 1590	33, ±10%
R3311	0203 1270	2M
R3312	0203 4400	6.8M, 1W
R3313	0203 4410	7.5M, 1W
R3315	0228 7400	wire wound, 910, 20W
R3316	0203 1730	470, ±10%
R3319	0203 1260	1.8M

RESISTORS (3400)

SYMBOL	PART NUMBER	DESCRIPTION
R3400 & R3401	0203 1770	1K, ±10%
R3402	0107 2341	variable, wire wound, 50, ±10%, 2W (SCALE ILLUM)
R3403 & R3404	0203 1770	1K, ±10%

SWITCHES

SYMBOL	PART NUMBER	DESCRIPTION
S110 (A101)	0501 6071	assembly, rotary, 30°, 2 decks, including (S112 & R1115) (Y VOLTS/CM)
S111 (R1122)	0107 2321	SPST (part of R1122) (INPUT)
S112 (R1115)	0107 2332	SPDT (part of R1115)
S120 (A102)	0501 6091	assembly, rotary, 30°, 5 decks, including (S122 & R1215) (X VOLTS/CM)
S121 (R1222)	0107 2321	SPST (part of R1222) (INPUT)
S122 (R1215)	0107 2332	SPDT (part of R1215)
S210 (A103)	0501 6081	assembly, rotary, 30°, 2 decks, including (S212 & R2106) (TRIGGER SOURCE)
S211	0500 2000	toggle, SPST (TRIG IN)
S212 (R2106)	0107 2333	SPST (part of R2106)
S220 (A104)	0501 6061	assembly, rotary, 20°, 2 decks, including (R2227) (TIME/CM)
S3200 (R3402)	0107 2341	SPST (part of R3402) (POWER)
S4000	0503 1200	relay, thermal
S4100	0503 1330	slide (FRONT/REAR)
S4200	0503 1330	slide (FRONT/REAR)

TRANSFORMERS

SYMBOL	PART NUMBER	DESCRIPTION
T3100	2001 3612	high-voltage
T3200	2001 3591	power

section 6
electrical parts list and schematics

SYMBOL	PART NUMBER	DESCRIPTION
R1221	0102 1440	variable, wire wound, 5K, 2W (X-DP LEVEL ADJ)
R1222	0107 2321	variable, 500 (X POSITION)
R1223 & R1224	0239 1417	film, 62K, 2W
R1225 & R1226	0203 1630	film, 68, ±10%
R1227	0234 5100	wire wound, 12K, 3W
R1228 & R1229	0234 4800	wire wound, 25K, 3W
R1230	0203 1690	220, ±10%
R1233	0203 2070	330K, ±10%
R1234 & R1235	0203 2050	220K, ±10%
R1236	0203 2070	330K, ±10%
R1241	0203 0440	680

RESISTORS (2100)

Notes: 1. All resistors are fixed, composition, ±5%, and ½W unless otherwise specified.

2. Resistance values in ohms: K = thousand
M = million

SYMBOL	PART NUMBER	DESCRIPTION
R2100	0204 1190	910K
R2101	0204 0970	110K
R2103	0204 1200	1M
R2104	0203 1730	470, ±10%
R2105	0203 0960	100K
R2106	0107 2333	variable, 1M (TRIG LEVEL)
R2107	0203 1070	300K
R2108	0203 0880	47K
R2109	0203 1000	150K
R2110	0203 2050	220K, ±10%
R2111	0203 0840	33K
R2112	0203 0810	24K
R2113	0108 6020	variable, 500 (TRIG LEVEL CENT)
R2114	0203 1730	470, ±10%
R2115	0203 0840	33K
R2116 & R2117	0203 0810	24K
R2118 & R2119	0203 1970	47K, ±10%
R2122	0203 1730	470, ±10%
R2123	0203 0580	2700
R2124 & R2125	0229 5130	film, 200K, ±1%
R2126	0203 1270	2M
R2127	0203 0640	4700
R2128	0203 1730	470, ±10%
R2129	0203 3800	22K, 1W

RESISTORS (2200)

SYMBOL	PART NUMBER	DESCRIPTION
R2200	0203 2200	3.9M, ±10%
R2201	0203 1060	270K
R2202	0203 2250	10M, ±10%
R2203	0203 1730	470, ±10%
R2204	0203 1020	180K
R2205	0203 0550	2K
R2206	0203 0520	1500
R2207	0203 0820	27K
R2208	0203 1020	180K
R2209	0203 0800	22K
R2211	0203 3820	27K, 1W
R2212	0229 5140	film, 243K, ±1%
R2213	0203 1020	180K
R2214	0203 0920	68K
R2215	0203 1090	360K
R2216	0229 5120	film, 140K, ±1%
R2217	0203 0880	47K
R2218	0203 1050	240K
R2221	0228 4100	film, 30K, 3W
R2222	0102 1440	variable, wire wound, 5K, 2W (SWEEP LENGTH)
R2223	0239 0326	film, 5100
R2224	0203 0950	91K
R2225	0108 6100	variable, 25K, 1/3W (100 µsec CAL)
R2226	0203 0700	8200
R2227	0107 2334	variable, 50K (VERNIER)
R2228 & R2229	0234 2300	film, 1.25M, ±1%
R2231	0234 2310	film, 2.5M, ±1%
R2232	0228 8370	film, 7.5M, ±1%
R2233	0229 9900	film, 12.5M, ±1%, 1W
R2234	0229 9910	film, 25M, ±10%, 1W
R2235	0203 1650	100, ±10%
R2236	0203 5020	120K, ±10%, 1W
R2237	0203 2010	100K, ±10%
R2238	0203 2110	680K, ±10%
R2239	0203 1650	100, ±10%
R2242	0203 1020	180K
R2243	0203 0820	27K
R2244	0239 1425	film, 120K, 2W
R2245 F,R	0108 6850	variable, 250K/2.5K, 1W (SWP EXPANSION POINT AND SWP CAL)
R2246	0203 0550	2K
R2247	0203 0360	330
R2248	0203 0620	3900
R2250	0203 1020	180K
R2251	0203 0860	39K
R2252	0203 1090	360K
R2253	0203 1160	680K
R2254	0203 0620	3900
R2255	0203 0760	15K

RESISTORS (3100)

SYMBOL	PART NUMBER	DESCRIPTION
R3100	0203 8180	2.7M, ±10%, 2W
R3101	0107 1374	variable, 5M (FOCUS)
R3102	0203 8180	2.7M, ±10%, 2W
R3103	0203 1890	10K, ±10%
R3104	0203 2170	2.2M, ±10%
R3105	0108 6460	variable, 200K, 1W (ASTIG)
R3106	0229 3760	film, 10M, ±1%, 2W
R3107	0229 4960	film, 4.02M, ±1%
R3108	0108 6460	variable, 200K, 1W (PATTERN CORR)
R3109	0203 2090	470K, ±10%
R3110	0210 0770	wire wound, 3.3 ohms, ±10%

DU MONT
INSTRUMENT WARRANTY AND SERVICE NOTICE

WARRANTY

Allen B. Du Mont Laboratories, Inc. warrants that each new Cathode-ray Oscilloscope, Automotive Test Equipment, and other Electronic or Electrical Test or Measuring Equipment (hereinafter referred to as "Instrument") manufactured or sold by it, is free from defects in material or workmanship under normal use and service for a period of one year from the date of its sale to the first purchaser for use. If, upon examination by Du Mont, the Instrument is determined to be defective in workmanship or material, Du Mont will, subject to the conditions set forth below, either repair the defective part or replace it with a new part. Du Mont shall not be liable for any delay or failure to furnish a replacement part resulting directly or indirectly from any governmental restriction, priority or allocation or any other governmental regulatory order or action, nor shall Du Mont be liable for damages by reason of the failure of the Instrument to perform properly or for any consequential damages. This warranty does not apply to any Instrument that has been subject to negligence, accident, misuse or improper installation or operation or that in any way has been tampered with, altered or repaired by any person other than an authorized Du Mont service organization or an employee thereof, or to any Instrument whose serial number has been altered, defaced or removed, or to any Instrument purchased within, and thereafter removed beyond, the continental limits of the United States.

This warranty shall, at Du Mont's option, become void unless registration thereof is promptly effected as provided below. This warranty is in lieu of all other warranties, expressed or implied, and no one is authorized to assume any liability on behalf of Du Mont or impose any obligation upon it in connection with the sale of any Instrument, other than as stated above.

REGISTERING THE WARRANTY

To register this warranty, the enclosed warranty registration card must be properly filled out and mailed to the Instrument Service Department immediately upon receipt of the equipment. Complete information is necessary. BOTH THE TYPE NUMBER AND THE SERIAL NUMBER OF THE INSTRUMENT MUST BE GIVEN ON THIS CARD. Instruments must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time and to furnish merchandise in accordance with current specifications without incurring any liability to modify equipment previously sold, or to supply new equipment in accordance with earlier specifications excepting under the classification of special apparatus.

SERVICE

In order to insure service under our warranty, the enclosed warranty service card must be properly filled out and returned to the factory. In all cases where service or adjustment is requested, please first contact the factory or authorized depot, giving complete information concerning the nature of the failure and describing the manner in which the equipment was used when failure occurred. THE TYPE NUMBER AND SERIAL NUMBER of the equipment must also be given. In this way, much time can be saved and unnecessary inconvenience often avoided. When writing to the factory in this respect, address:

ALLEN B. DU MONT LABORATORIES, INC.
Instrument Service Department
Industrial Electronics Division
750 Bloomfield Avenue, Clifton, New Jersey

The Instrument Service Department will then send to the customer the written procedure for disposition and shipping instructions. All equipment should be packed and shipped in accordance with this procedure; and identification tags should be attached to each tube or instrument.

REPLACEMENT PARTS

If it is necessary to order a replacement component from the factory, always give the Type number and Serial number of the Instrument. Before ordering parts for in-warranty replacement or purchasing them for out-of-warranty replacement, be sure to consult the Parts List in the Instruction Manual. The Parts List gives the values, tolerances, ratings, and Du Mont part number for all electrical components used in the Instrument. This will help to expedite service.

ALLEN B. DU MONT LABORATORIES, INC.
Industrial Electronics Division
750 Bloomfield Avenue, Clifton, New Jersey

PATENT NOTICE

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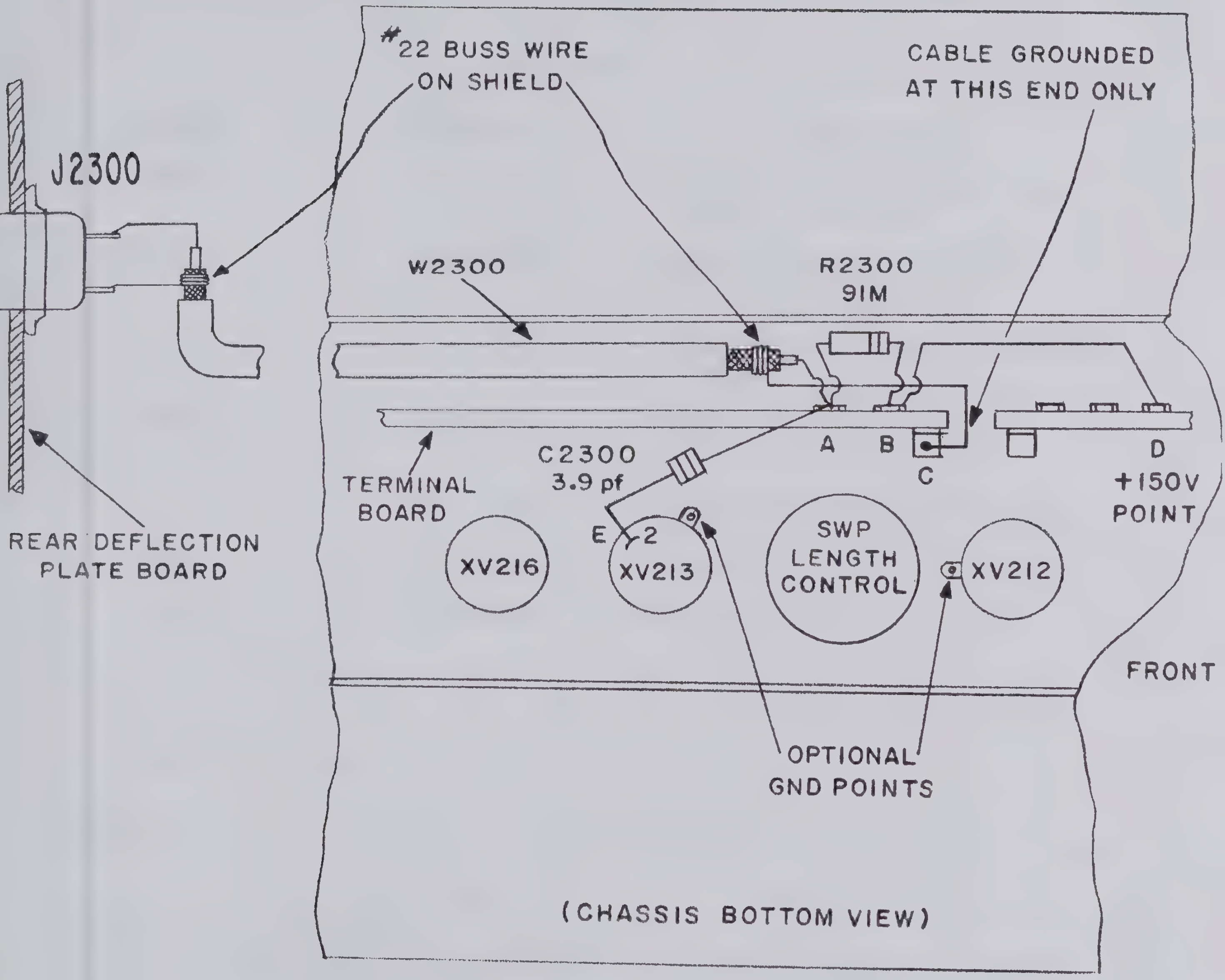
section 6
electrical parts list and schematics

SYMBOL	PART NUMBER	DESCRIPTION
	ELECTRON TUBES	
V110 & V111	2501 1610	ECC82/12AU7
V112	2501 2220	ECC88/6DJ8
V120 & V121	2501 1610	ECC82/12AU7
V122	2501 2220	ECC88/6DJ8
V210 & V211	2501 2220	ECC88/6DJ8
V212	2500 8250	6BC7
V213	2500 8220	12AV7
V214	2500 8250	6BC7
V215	2501 1980	6BR8A
V216	2501 1610	ECC82/12AU7
V310	2500 5740	5642
V313	2501 1670	6CZ5
V314	2501 1610	ECC82/12AU7

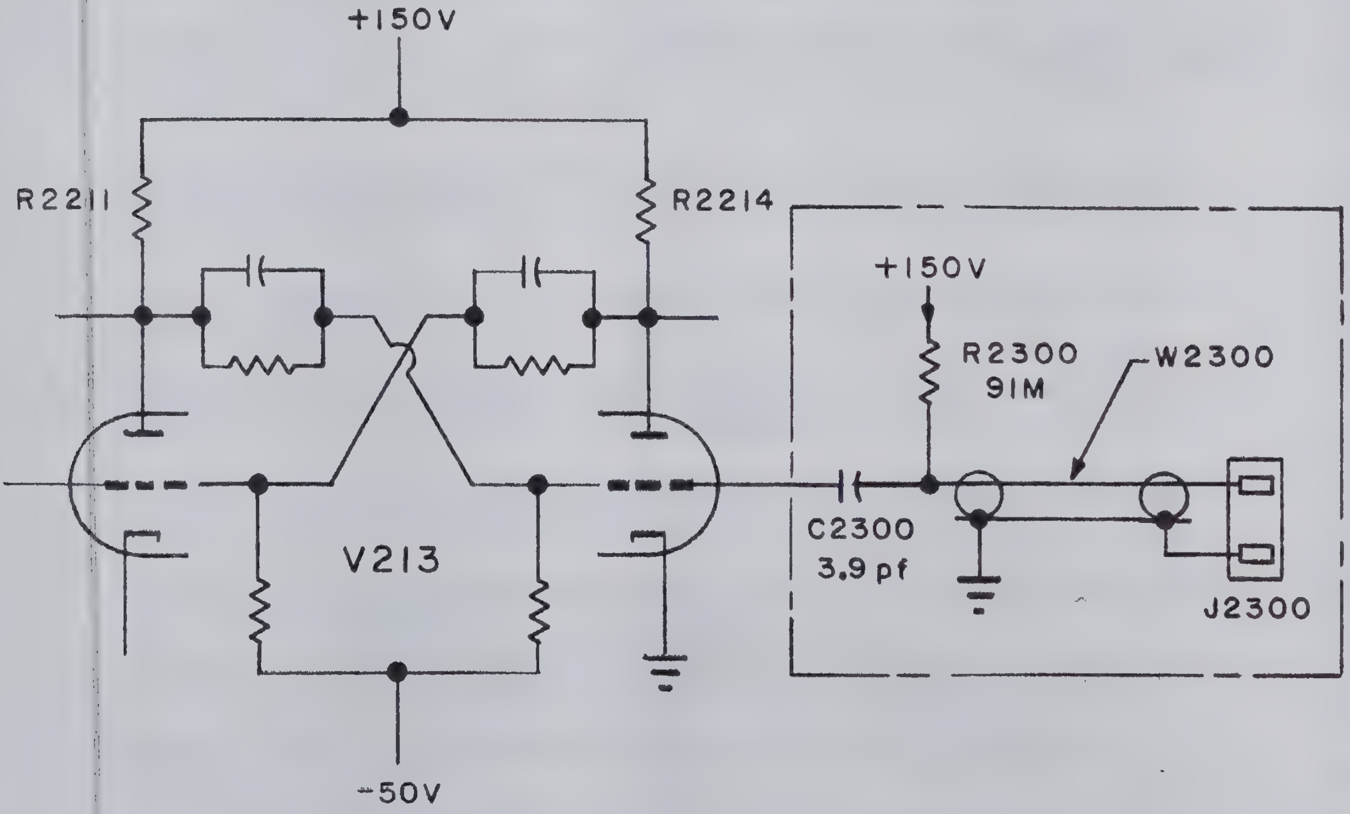
SYMBOL	PART NUMBER	DESCRIPTION
V315*	2501 2510	K1931-P1
	2501 2520	K1931-P2
	2501 2530	K1931-P7
	2501 2540	K1931-P11
* Depending on sales order		
V320	2501 1970	6BJ8
V321	2501 1560	5AR4/GZ-34
V322	2501 1980	6BR8A
V323	2500 9270	OG3/85A2
V324	2501 0200	6AS7-GA
V325	2501 1980	6BR8A
	CABLE	
W3200	5026 9641	assembly, power


#22 BUSS WIRE
ON SHIELD
CABLE GROUNDED
AT THIS END ONLY
J2300
W2300
R2300
91M
TERMINAL
BOARD
C2300
3.9 pf
A
B
C
D
+150V
POINT
E
2
XV216
XV213
SWP
LENGTH
CONTROL
XV212
REAR DEFLECTION
PLATE BOARD
FRONT
OPTIONAL
GND POINTS
(CHASSIS BOTTOM VIEW)

On Schematic Part Number 9800 2101-4, Sheet 2 of 3, add the following parts shown blocked in on attached schematic diagram.

PARTS LIST

Symbol	Part No.	Description
C2300	0313 3910	Capacitor, fixed, composition, 3.9 pf, ±10%, 500V
R2300	0204 2300	Resistor, fixed, composition, 91 megohms, ±20%, 1/2W
J2300	0901 5560	Connector, receptacle, 2 contacts, female
W2300	5029 6240	Cable, RF,
_____	6009 8570	Screw, binder head, 6-32 x 3/8
_____	6210 0030	Washer, lock #6
_____	6100 0600	Nut, hex, 6-32



ADDENDUM

FOR INSTRUCTION MANUAL OF

TYPES 401-B/401-BR OSCILLOSCOPES (Manual #6703 8931)

The purpose of this addendum is to add the Accessory, Du Mont Type 4001, Sweep Rearming Kit to this manual.

The Du Mont Type 4001 Sweep Rearming Kit has been designed to enable the sweep to be armed remotely by means of a contact closure introduced through the two-contact socket (J2300) to be installed on the rear deflection plate board as part of this kit installation.

To install the Sweep Rearming Kit, follow the steps outlined and reference the pictorial and simplified schematic attached.

1. Set the Oscilloscope on a bench with the bottom up. Locate the area in which the Kit parts are to be installed. See pictorial.
2. Connect the center conductor of the RF Cable supplied,to Point A.
3. Connect the buss wire, which is soldered to the shield, to the terminal board mounting foot Point C. Optional ground points on sockets XV212 or XV213 may be used if desired.
4. Run cable back alongside terminal boards, under the Erie board, up through rear transformer ventilating hole to area of cutout on the rear deflection plate board.
5. Install connector (J2300) on rear deflection plate board using the hardware provided.
6. Dress the coaxial cable up to the connector and solder the center conductor to the top terminal of the connector.
7. Connect the buss wire, which is soldered to the shield, to the bottom terminal (indicated with ground symbol) of the connector.
8. Connect a jumper lead between points B and D. This connection applies +150 volts to point B.
9. Connect the 91-megohm resistor (R2300) across points A and B.
10. Connect the 3.9 pf capacitor (C2300) from pin 2 of V213 (Point E) to terminal board point A.

This completes the installation of the Sweep Rearming Kit.

ADDENDUM

FOR INSTRUCTION MANUAL OF

TYPES 401-B/401-BR OSCILLOSCOPES (Manual #6703 8931)

The changes described below were made in order to bring the Parts List up-to-date to agree with the Schematic Drawing Part Number 9800 2101-4.

	Symbol		Part Number	Description
Add	R3226		0203 2880	Resistor, fixed, composition, 2M ohms, ±10%, 1/2W
Change	R3220	from	0203 1940	Resistor, fixed, composition, 2700 ohms, ±10%, 1/2W
		to	0203 1940	Resistor, fixed, composition, 27K ohms, ±10%, 1/2W
Change	C1220	from	0319 0310	Capacitor, fixed, ceramic, 0.04 uf, 600V
		to	0317 5830	Capacitor, fixed, ceramic, 0.04 uf, 600V

ALLEN B. DU MONT LABORATORIES, INC.
INSTRUMENT ENGINEERING DEPARTMENT
INDUSTRIAL ELECTRONICS DIVISION
750 BLOOMFIELD AVENUE, CLIFTON, NEW JERSEY

#6704 0161
Sheet 1 of 1

ADDENDUM FOR INSTRUCTION MANUAL OF

TYPES 401-B/401-BR OSCILLOSCOPES

ADDENDUM CHANGE NUMBER 6704 0101

This change was made in order to compensate for the unbalance in the Trigger Amplifier and Level Selector circuit.

A 200K, ± 5%, 1/2W, Resistor (Du Mont Part Number 0203 1030) may be added in shunt with either R2116 or R2117 to compensate for unbalance in the plate circuit of V210; tube type 6DJ8.

	Symbol	Part Number	Description
Add	R3126	0203 1910	Resistor, fixed, composition, 15K ohms, ±10%, 1/2W

On Schematic Drawing #9800 2101-4, Sheet 3 of 3, add R3126, 15K ohms, between the ground end of Transformer T3100 and ground.

B. ADDENDUM CHANGE NUMBER 6703 8991

This change was made in order to improve reliability of sweep calibration.

	Symbol		Part Number	Description
Add	R3405		0210 5120	Resistor, fixed, wire wound, 3.3 ohms, ±10%, 2W
Change	CR3101 & CR3102	from	2600 6620	Diode, selenium
		to	2600 2711	Rectifier, metallic, selenium

On Schematic Drawing #9800 2101-4, Sheet 3 of 3, add R3405, 3.3 ohms in series with Pin 4 heater lead of V214.

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INDUSTRIAL ELECTRONICS DIVISION
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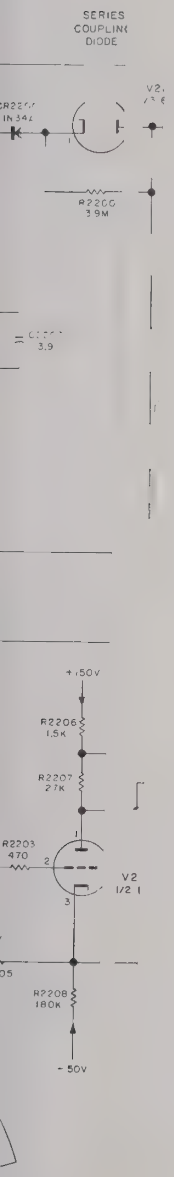
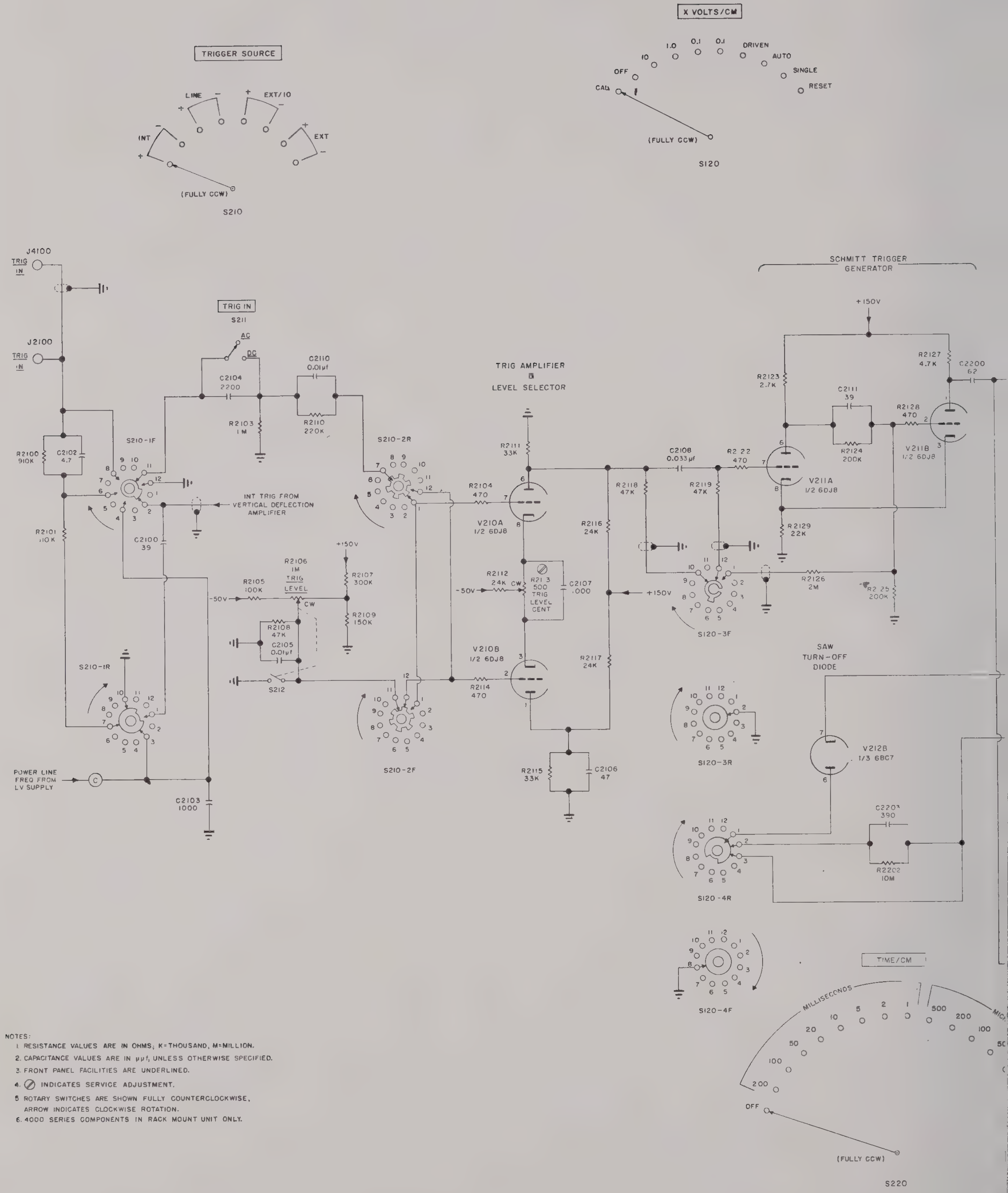

SERIES
COUPLING
DIODE
V2
1N34
R2200
3.9M
3.9
+150V
R2206
1.5K
R2207
27K
R2203
470
V2
1/2
R2208
180K
-50V



NOTES:

1. RESISTANCE VALUES ARE IN OHMS; K=THOUSAND, M=MILLION.
2. CAPACITANCE VALUES ARE IN μμf, UNLESS OTHERWISE SPECIFIED.
3. FRONT PANEL FACILITIES ARE UNDERLINED.
4. ⊘ INDICATES SERVICE ADJUSTMENT.
5. ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE, ARROW INDICATES CLOCKWISE ROTATION.
6. 4000 SERIES COMPONENTS IN RACK MOUNT UNIT ONLY.

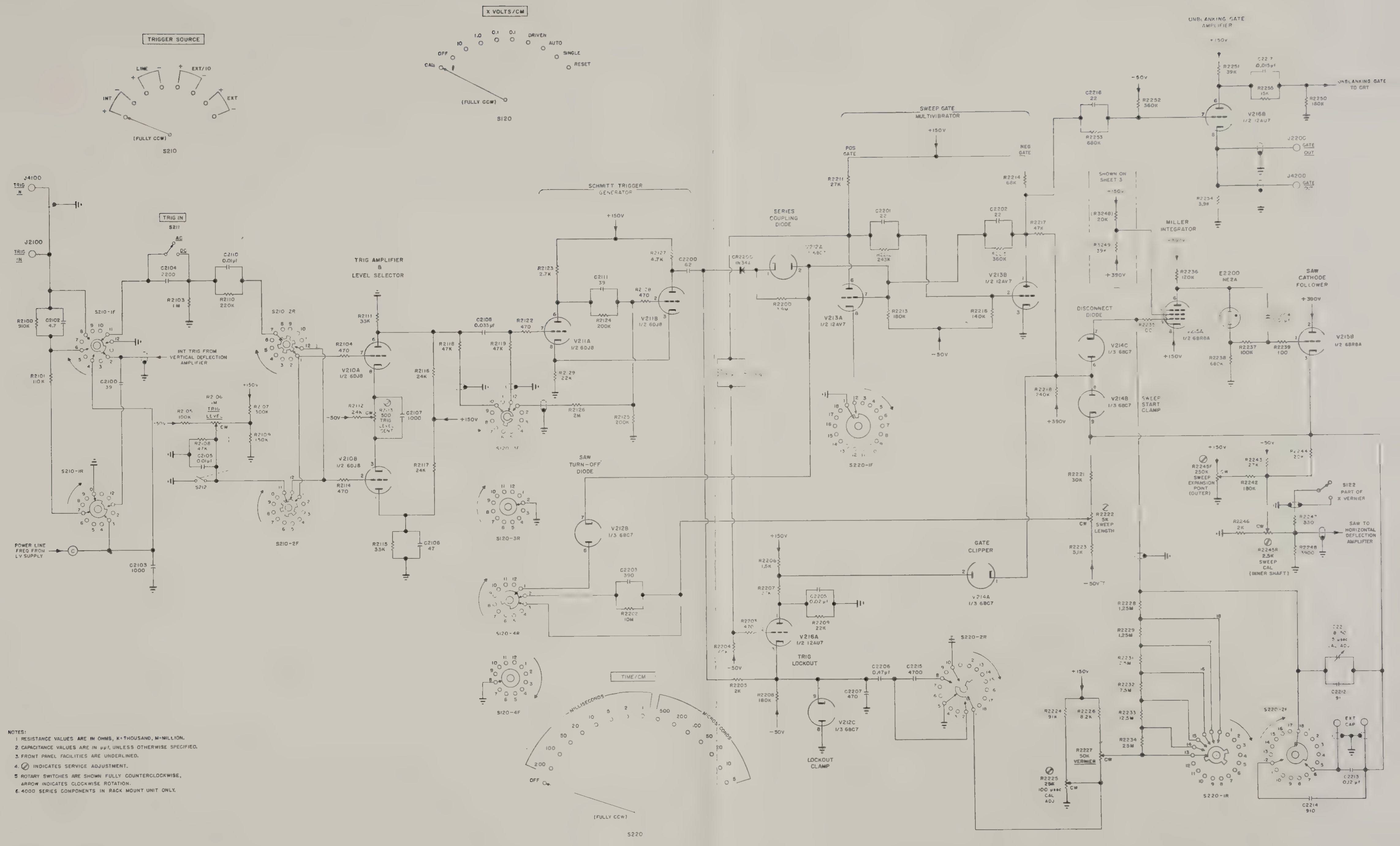


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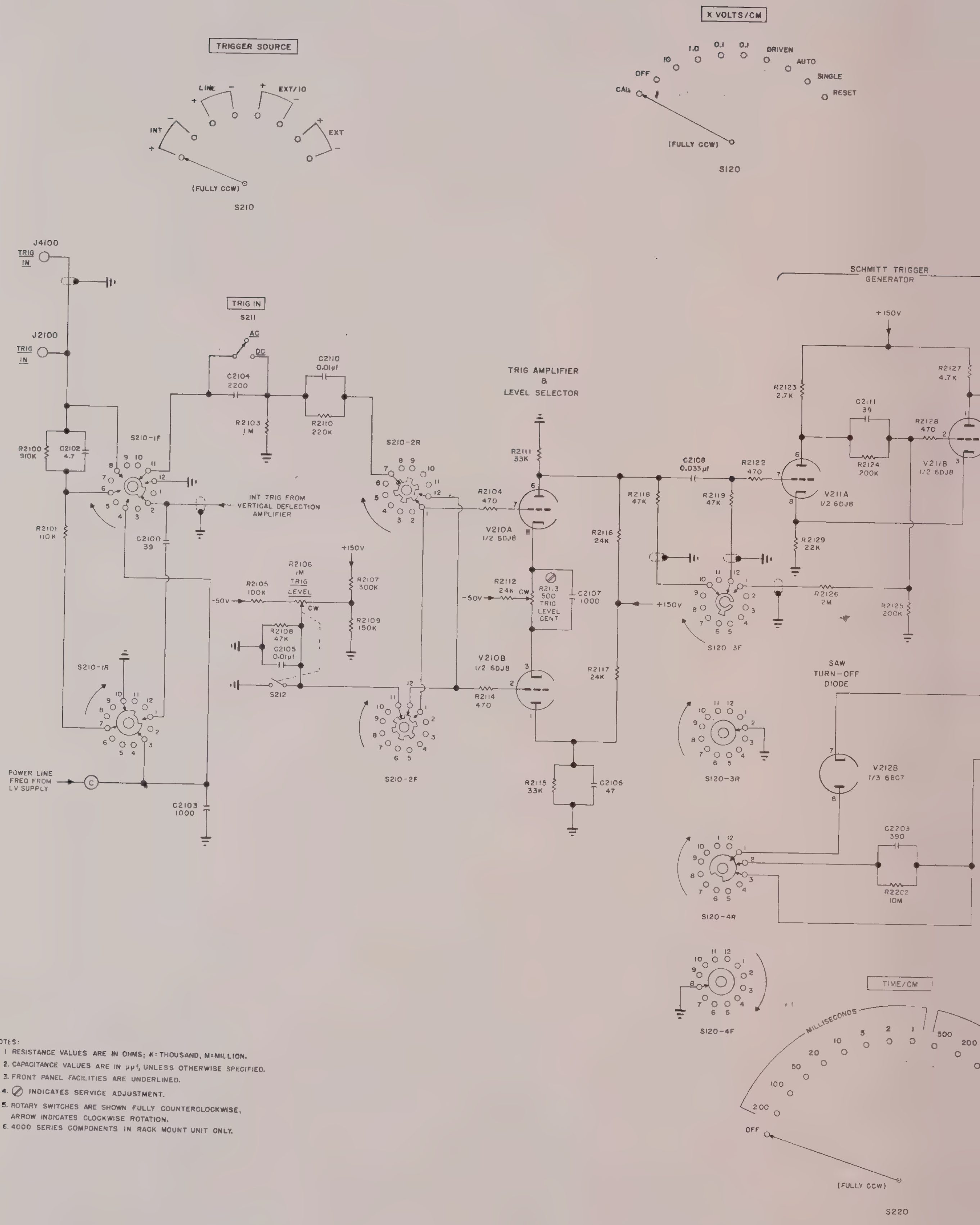
Figure 6-2. Schematic, Trigger and Sweep Circuits, Du Mont Type 401-B/401-BR Oscilloscopes (Reference Drawing 9800 2101-4, Sheet 2 of 3)



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4. ⊘ INDICATES SERVICE ADJUSTMENT.
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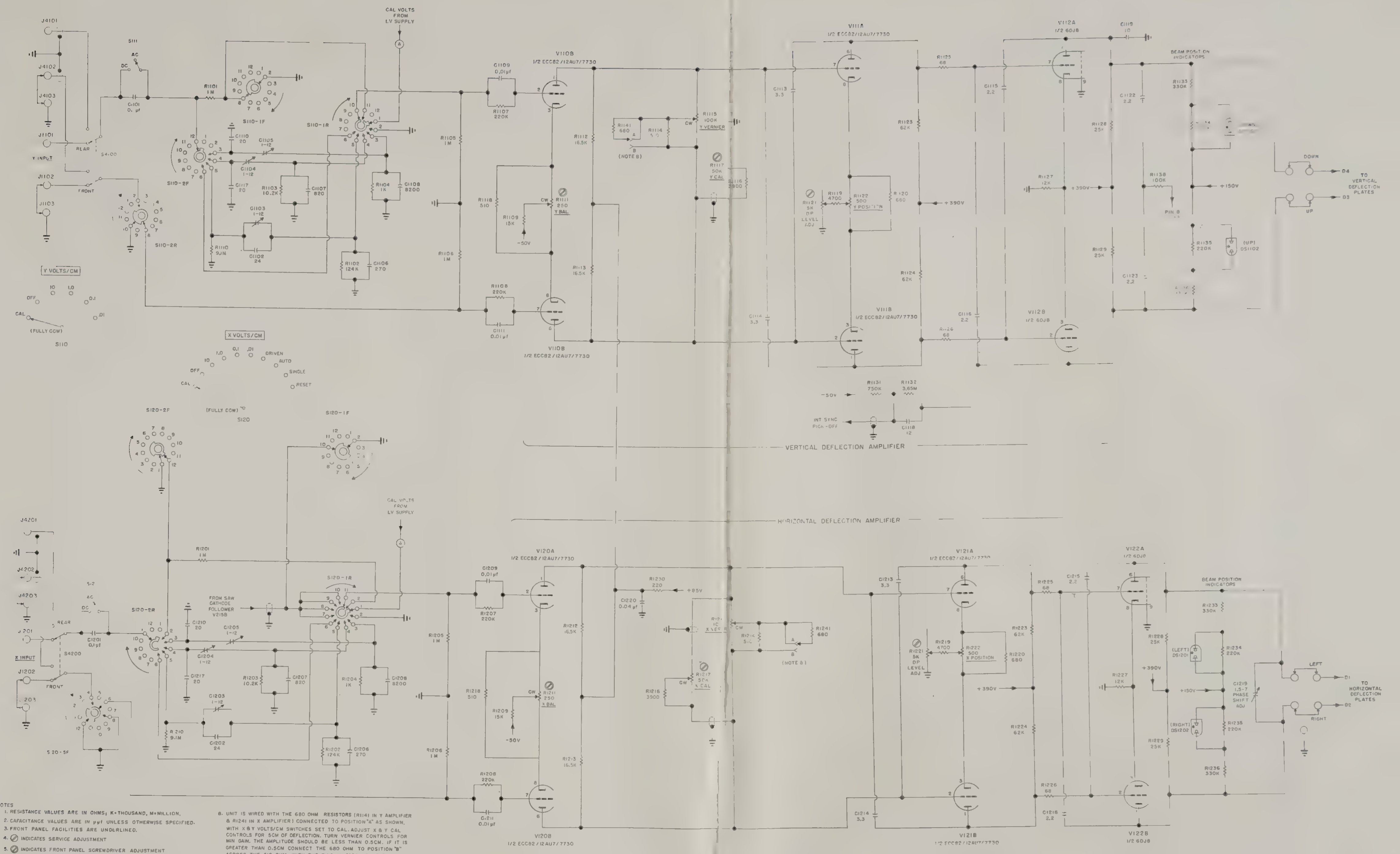

NOTES
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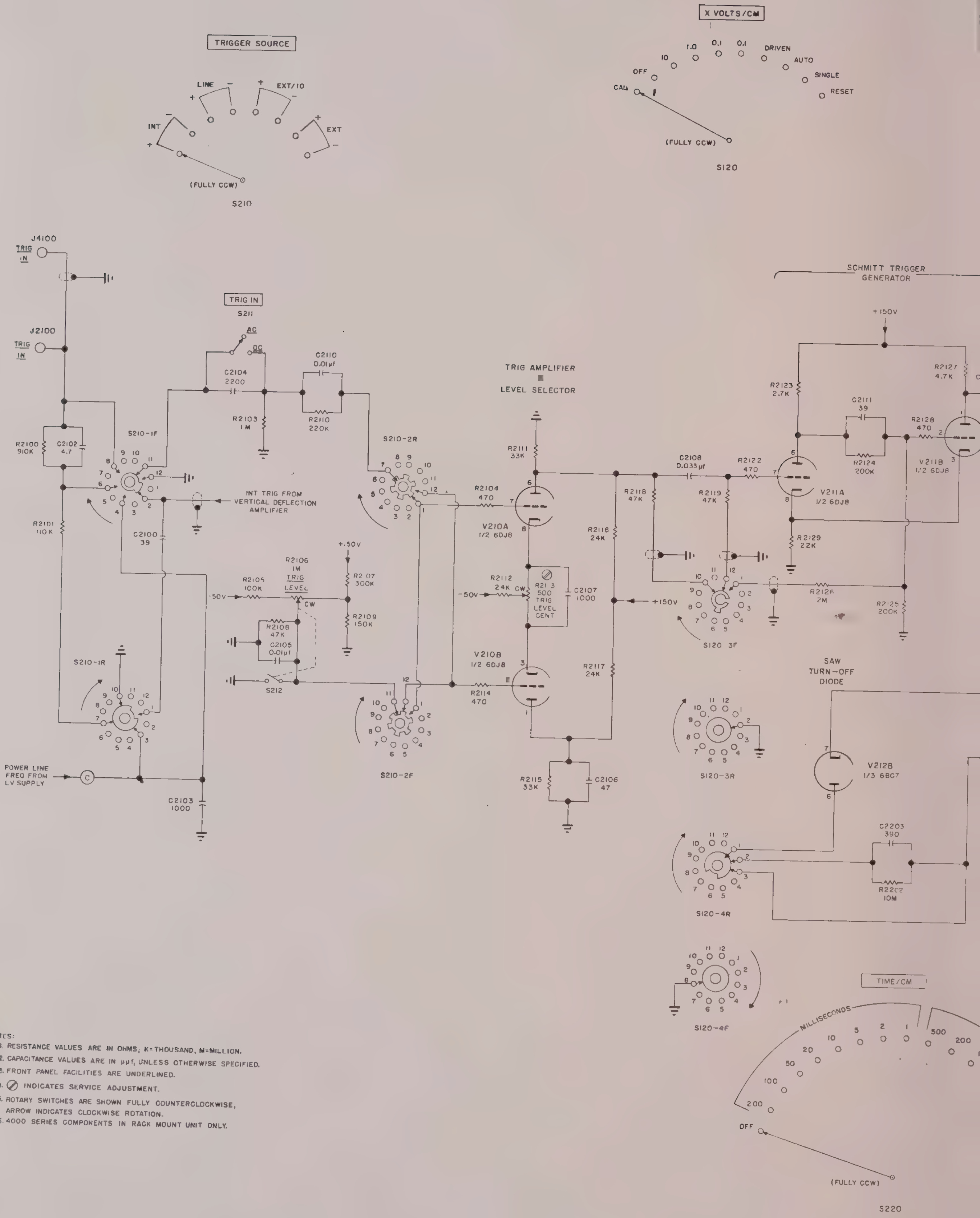
2. CAPACITANCE VALUES ARE IN µµf UNLESS OTHERWISE SPECIFIED.
3. FRONT PANEL FACILITIES ARE UNDERLINED.
4. ⊘ INDICATES SERVICE ADJUSTMENT
5. ⊘ INDICATES FRONT PANEL SCREWDRIVER ADJUSTMENT
6. ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE, ARROW INDICATES CLOCKWISE ROTATION
7. 4000 SERIES COMPONETS IN RACK MOUNT UNIT ONLY.
8. UNIT IS WIRED WITH THE 680 OHM RESISTORS (R1141 IN Y AMPLIFIER & R1241 IN X AMPLIFIER) CONNECTED TO POSITION "A" AS SHOWN. WITH X & Y VOLTS/CM SWITCHES SET TO CAL. ADJUST X & Y CAL CONTROLS FOR 5CM OF DEFLECTION. TURN VERNIER CONTROLS FOR MIN GAIN. THE AMPLITUDE SHOULD BE LESS THAN 0.5CM. IF IT IS GREATER THAN 0.5CM CONNECT THE 680 OHM TO POSITION "B" ACROSS THE 510 OHM. WITH THE TWO IN PARALLEL THE RESIDUAL GAIN SHOULD BE GREATER THAN 0.3CM.

Figure 6-1. Schematic, X & Y Deflection Amplifiers, Du Mont Type 401-B/401-BR Oscilloscopes (Reference Drawing 9800 2101-4, Sheet 1 of 3)



NOTES:

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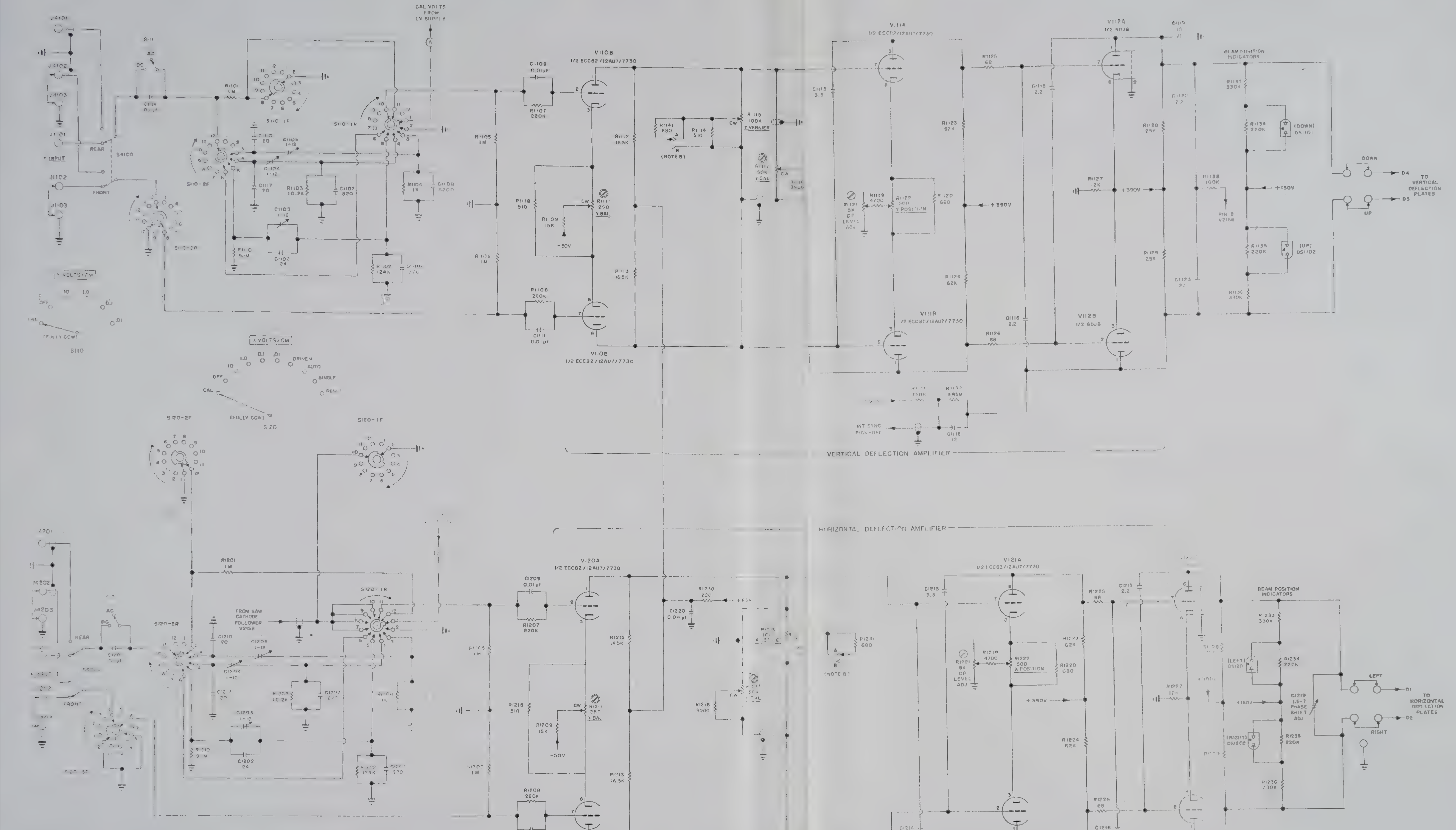
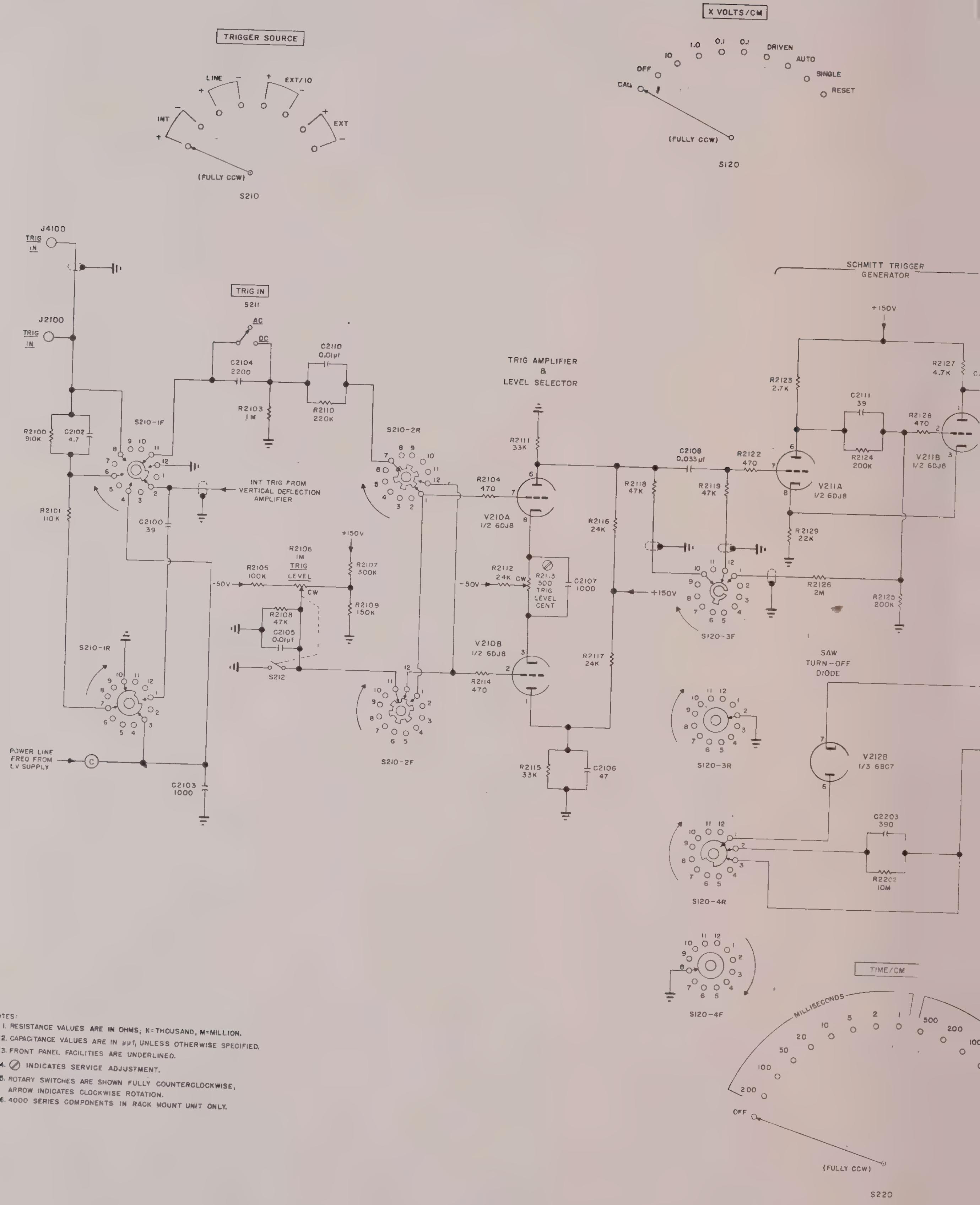
2. CAPACITANCE VALUES ARE IN μμf, UNLESS OTHERWISE SPECIFIED.
3. FRONT PANEL FACILITIES ARE UNDERLINED.
4. ⊘ INDICATES SERVICE ADJUSTMENT.
5. ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE, ARROW INDICATES CLOCKWISE ROTATION.
6. 4000 SERIES COMPONENTS IN RACK MOUNT UNIT ONLY.



RESISTANCE VALUES ARE IN OHMS, K=THOUSAND, M=MILLION.
CAPACITANCE VALUES ARE IN μμf UNLESS OTHERWISE SPECIFIED.
FRONT PANEL FACILITIES ARE UNDERLINED.
⊘ INDICATES SERVICE ADJUSTMENT
⊘ INDICATES FRONT PANEL SCREWDRIVER ADJUSTMENT
ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE, ARROW INDICATES CLOCKWISE ROTATION
4000 SERIES COMPONENTS IN RACK MOUNT UNIT ONLY.

8. UNIT IS WIRED WITH THE 680 OHM RESISTORS (R1141 IN Y AMPLIFIER & R1241 IN X AMPLIFIER) CONNECTED TO POSITION "A" A[illegible] WITH X & Y VOLTS/CM SWITCHES SET TO CAL. ADJUST X & Y CAL CONTROLS FOR 5CM OF DEFLECTION. TURN VERNIER CONTROLS FOR MIN GAIN. THE AMPLITUDE SHOULD BE LESS THAN 0.5CM. IF IT IS GREATER THAN 0.5CM CONNECT THE 680 OHM TO POSITION B' ACROSS THE 510 OHM. WITH THE TWO IN PARALLEL THE RESIDUAL GAIN SHOULD BE GREATER THAN 0.3CM.

Figure 6-1. Schematic, X & Y Deflection Amplifiers, Du Mont Type 401-B/401-BR Oscilloscopes (Reference Drawing 9800 2101-4, Sheet 1 of 3)



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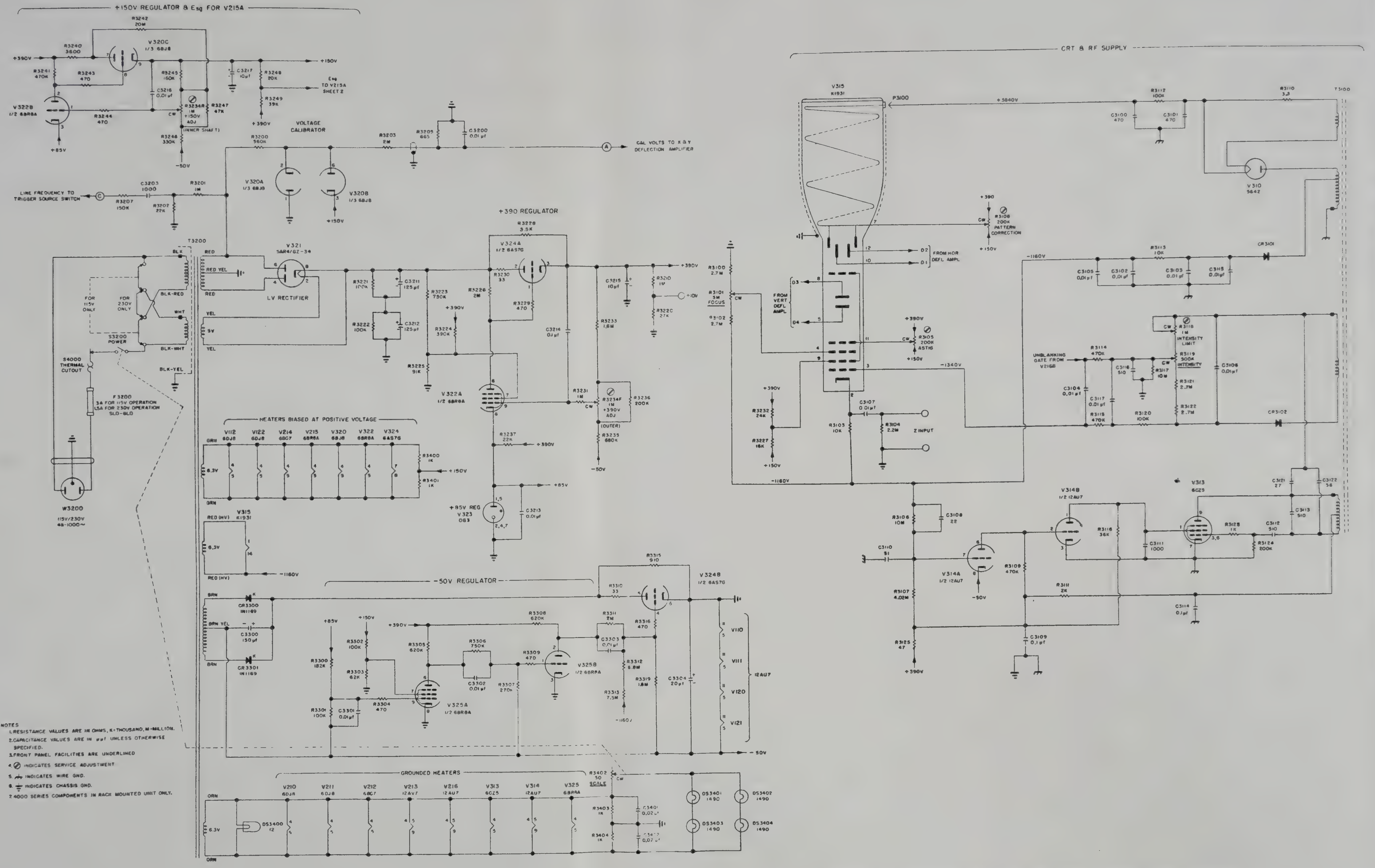
4. ⊘ INDICATES SERVICE ADJUSTMENT.
5. ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE, ARROW INDICATES CLOCKWISE ROTATION.
6. 4000 SERIES COMPONENTS IN RACK MOUNT UNIT ONLY.



NOTES

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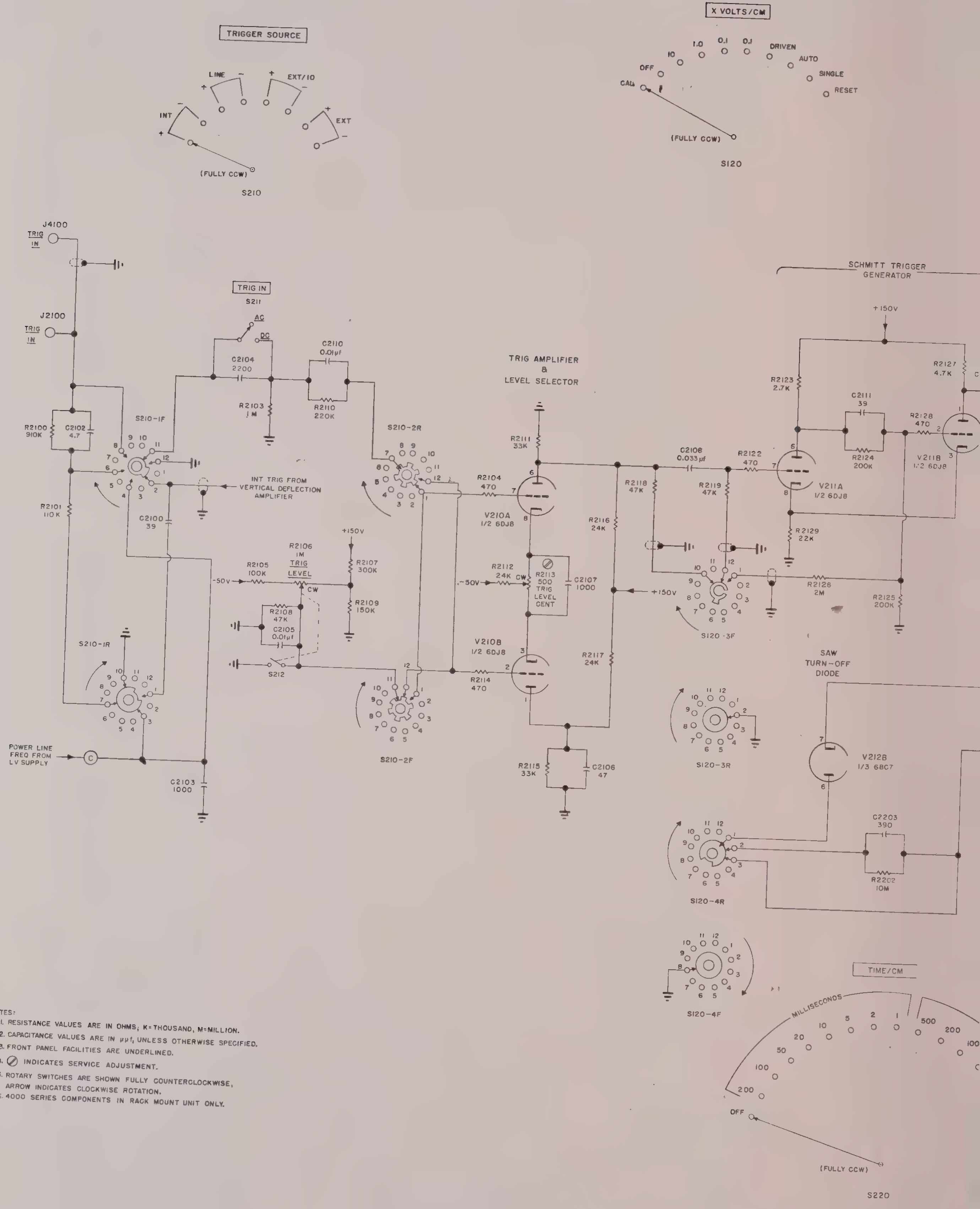
2. CAPACITANCE VALUES ARE IN μμf UNLESS OTHERWISE SPECIFIED.
3. FRONT PANEL FACILITIES ARE UNDERLINED
4. ⊘ INDICATES SERVICE ADJUSTMENT
5. ⏚ INDICATES WIRE GND.
6. ⏚ INDICATES CHASSIS GND.
7. 4000 SERIES COMPONENTS IN RACK MOUNTED UNIT ONLY.

Figure 6-3. Schematic, CRT, Low and High Voltage Power Supplies Du Mont Type 401-B/401-BR Oscilloscopes (Reference Drawing 9800 2101-4, Sheet 3 of 3)



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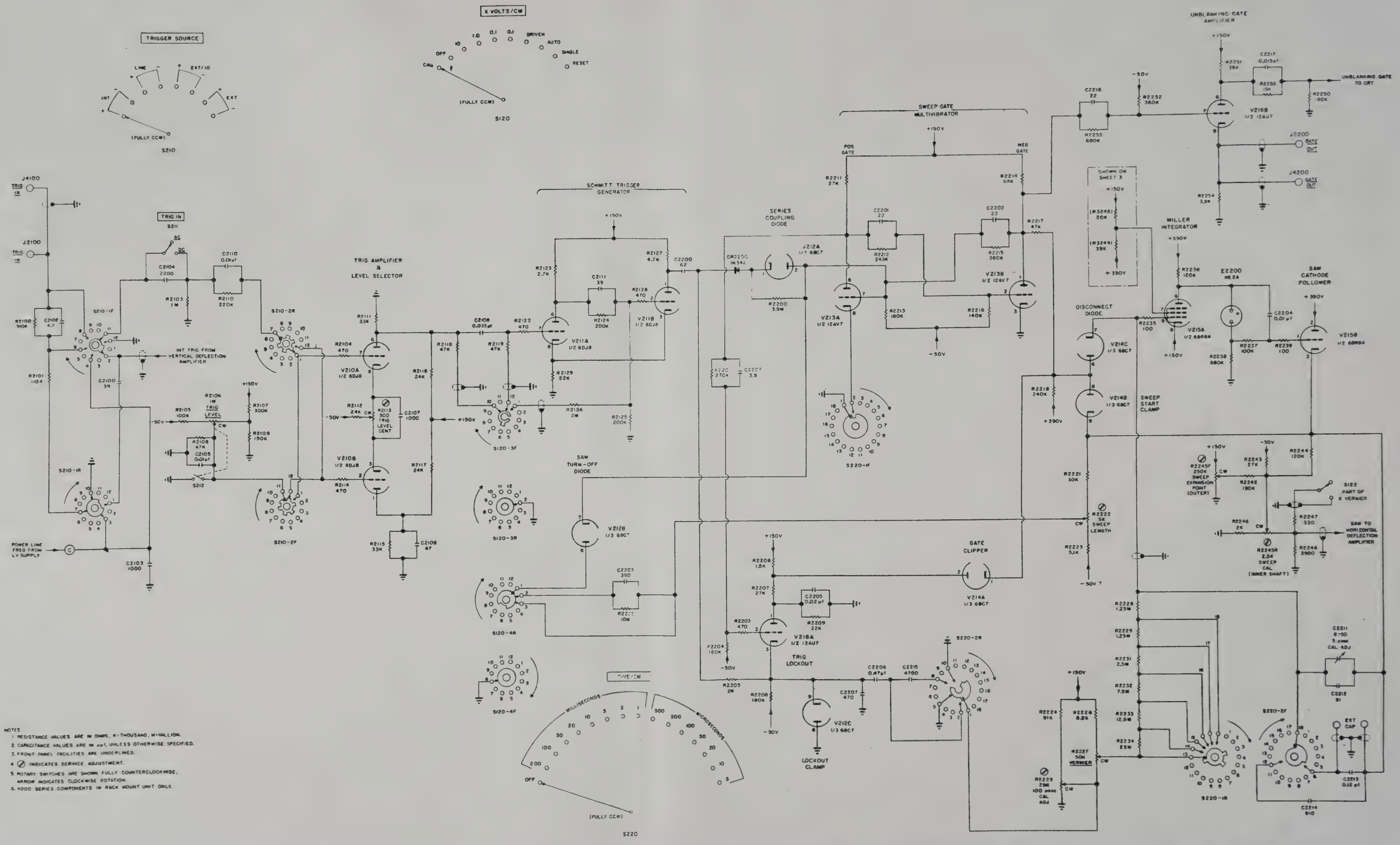

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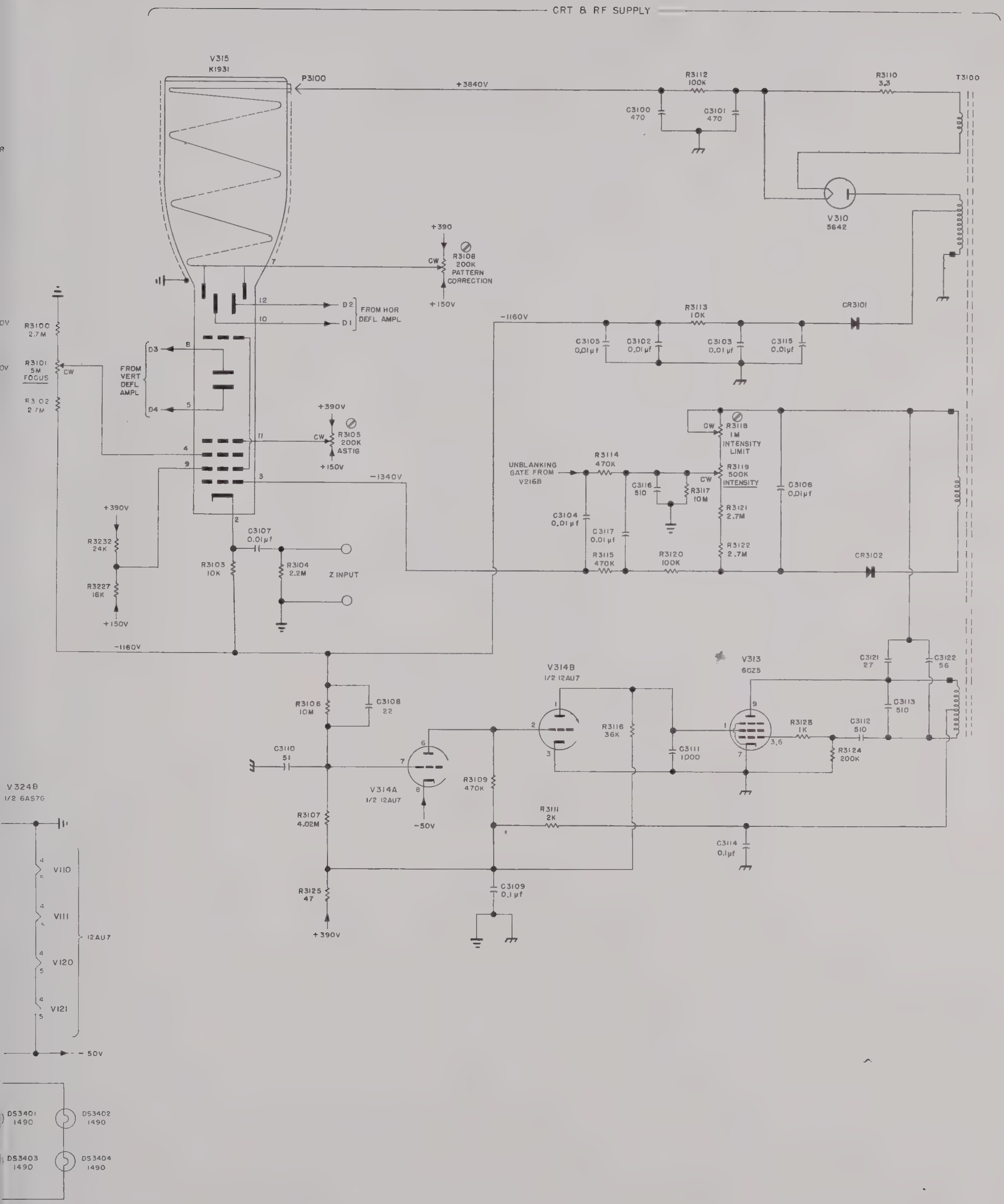
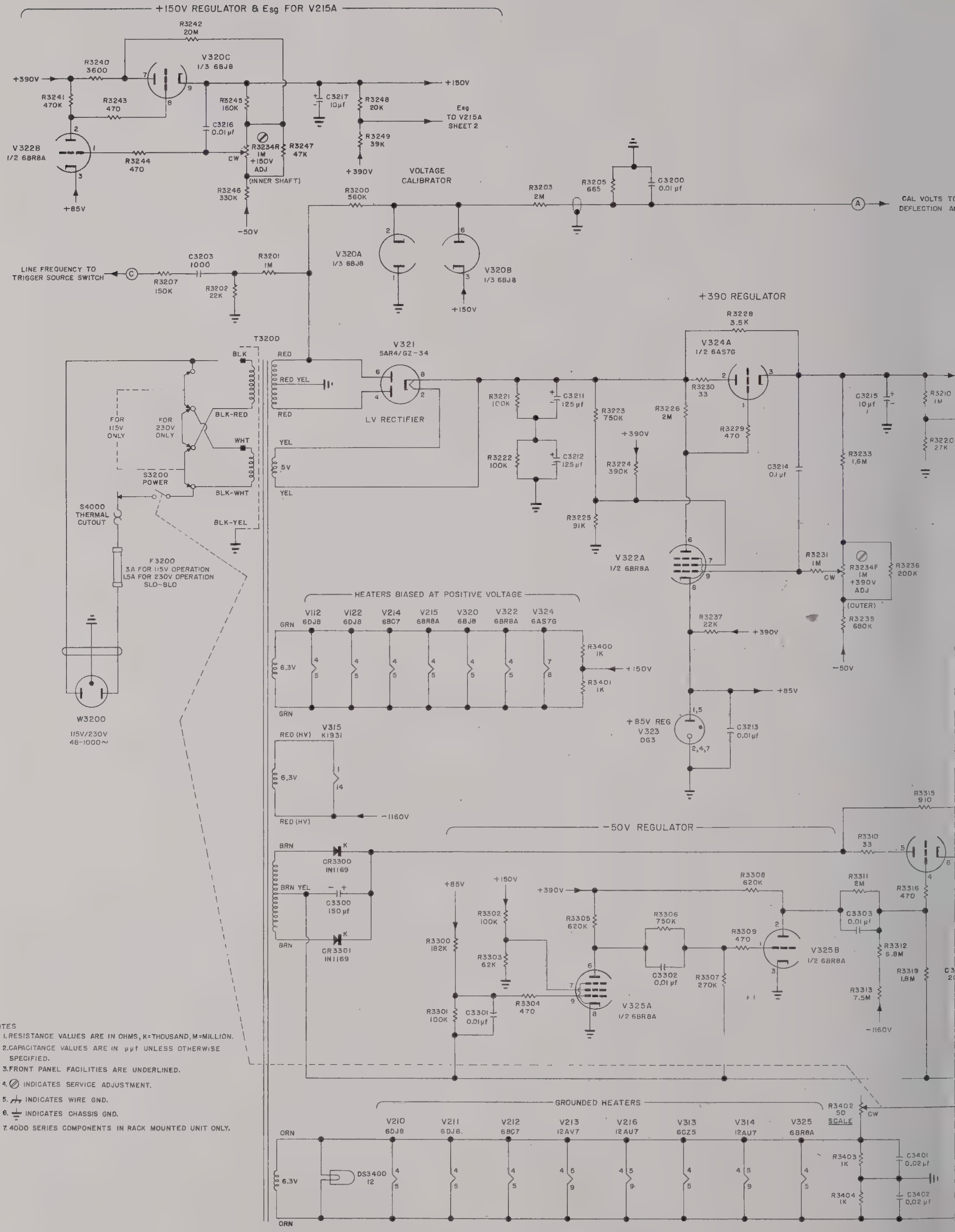


Figure 6-3. Schematic, CRT, Low and High Voltage Power Supplies Du Mont Type 401-B/401-BR Oscilloscopes (Reference Drawing 9800 2101-4, Sheet 3 of 3)



NOTES
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2. CAPACITANCE VALUES ARE IN µµf UNLESS OTHERWISE SPECIFIED.
3. FRONT PANEL FACILITIES ARE UNDERLINED.
4. ⊘ INDICATES SERVICE ADJUSTMENT.
5. ⏚ INDICATES WIRE GND.
6. ⏚ INDICATES CHASSIS GND.
7. 4000 SERIES COMPONENTS IN RACK MOUNTED UNIT ONLY.

Du Mont

Cathode-ray Oscillograph

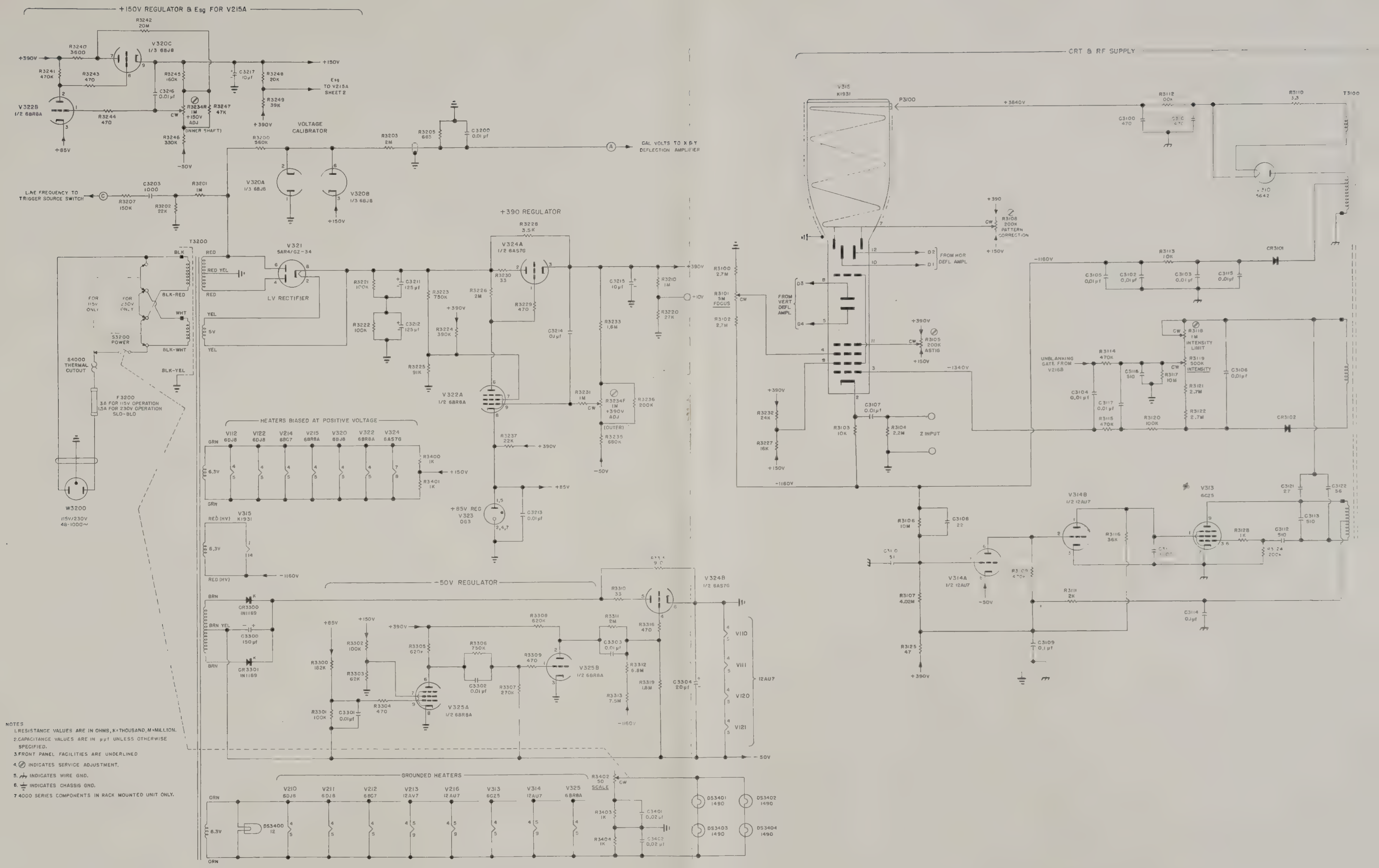
TYPE 304-A

OPERATING AND MAINTENANCE MANUAL

Allen B. Du Mont Laboratories, Inc.

Instrument Division

CLIFTON • • • NEW JERSEY



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Du Mont

Cathode-ray Oscillograph

TYPE 304-A

OPERATING AND MAINTENANCE MANUAL

Allen B. Du Mont Laboratories, Inc.
Instrument Division
CLIFTON • • • NEW JERSEY

In developing this instrument, an attempt has been made to incorporate circuits the characteristics of which, we believe, will satisfy the greatest number of applications, and to this end many circuit combinations have been included to extend its flexibility and versatility.

We feel, however, that the real test of any instrument is the opinion of the man who uses it. This day-to-day test of the instrument's advantages and limitations will prove, more than any other method, just what characteristics are desirable, why the range of any given component or function of the equipment should be extended, and how important such modification is.

Because of the nature of the equipment manufactured by Allen B. Du Mont Laboratories, Inc., it is only by complete cooperation between the customer and our Engineering Department that satisfactory designs can be achieved. In an attempt to continually extend the applicability of our equipment to the problems of the engineer, we sincerely request suggestions advising in what manner the design of this equipment may be further extended to include these problems.

TYPES 304-A and 304-AR CATHODE-RAY OSCILLOGRAPHS

REVISION SHEET

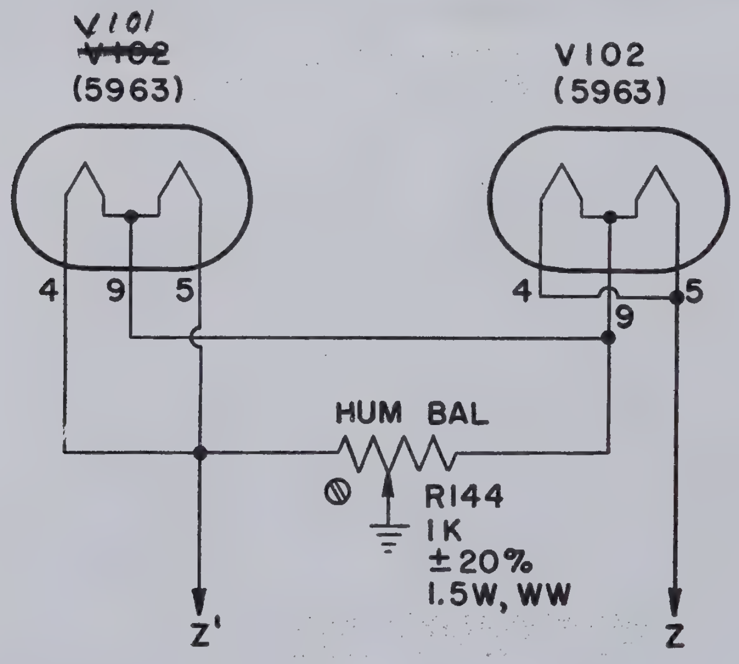
To improve operation and to facilitate adjustment of the Types 304-A and 304-AR, certain changes in the circuit have been made as follows: These changes should be noted when following the information presented in the instructional manual.

SCHEMATIC PARTS CHANGES:

1. R317 changed from 24K to 20K; Part No. 02030790.
2. C103 changed from 100 μμf to 82 μμf; Part No. becomes 03020420.
3. R412 changed from 10K to 22K ±5%; Part No. becomes 02030800.
4. R144 added; Part No. 01053600, 1000 ohms ±20%, 1.5 watt, wire-wound.
5. R406 changed from 270K to 220K; Part No. becomes 02035050.
6. R318 changed from 100K to 68K; Part No. becomes 02037990.

SCHEMATIC WIRING CHANGES:

1. The heater circuit of V101 and V102 has been rewired as shown to incorporate a HUM BALance control.

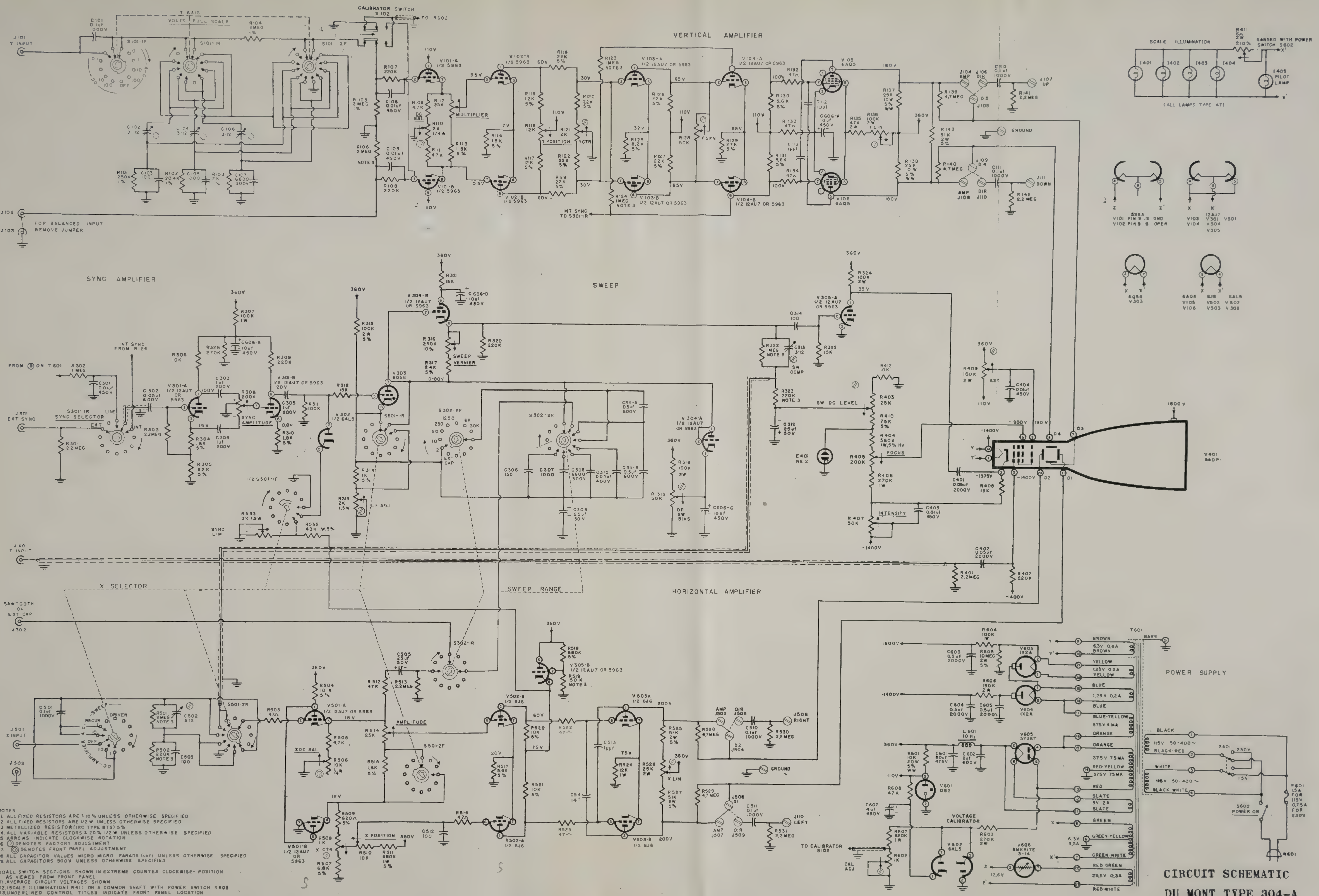


Part No. 67011043

ALLEN B. DU MONT LABORATORIES, INC.

INSTRUMENT DIVISION

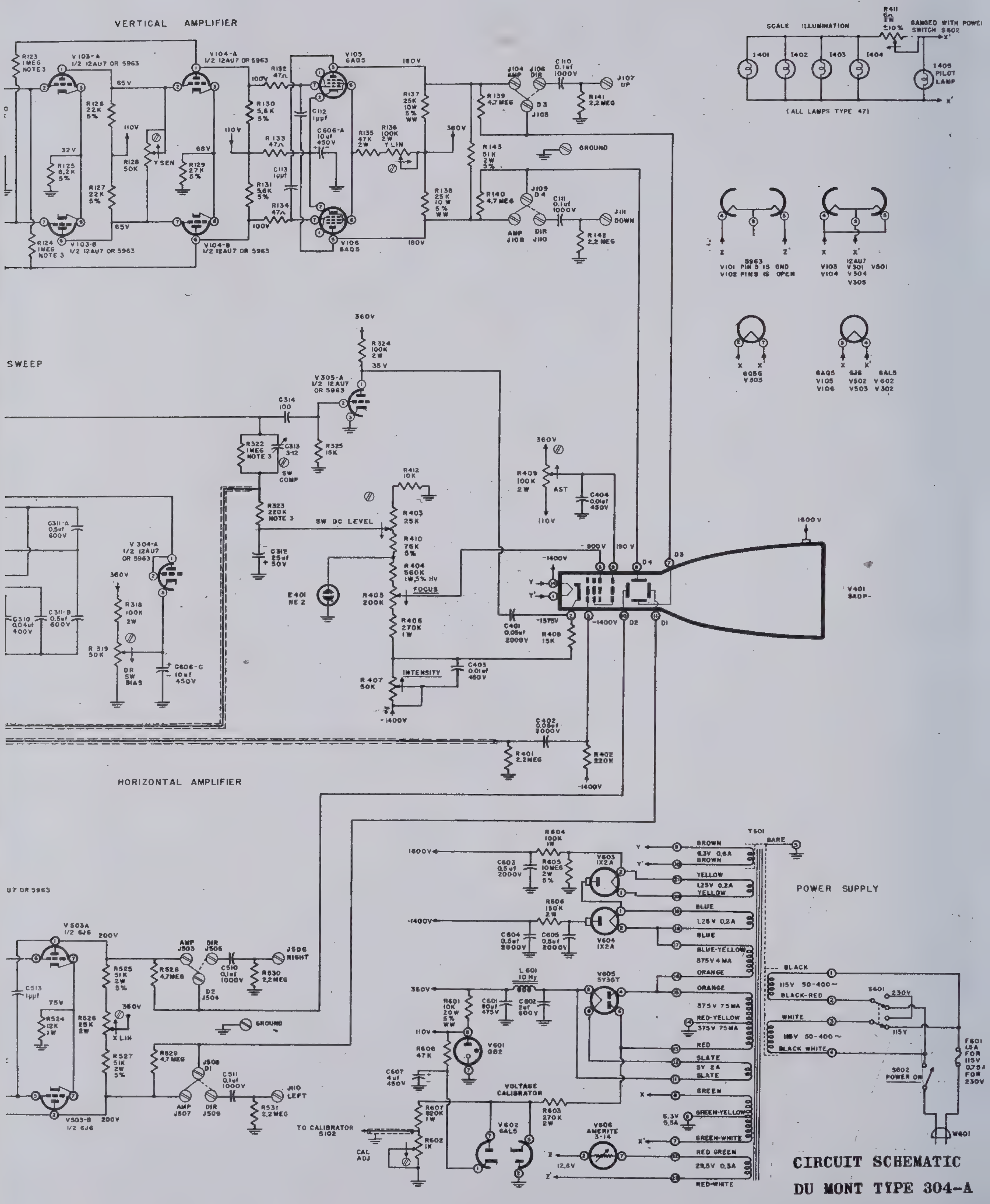
1500 MAIN AVENUE, CLIFTON, N.J., U.S.A.



NOTES

1. ALL FIXED RESISTORS ARE ±10% UNLESS OTHERWISE SPECIFIED
2. ALL FIXED RESISTORS ARE 1/2 W UNLESS OTHERWISE SPECIFIED
3. METALLIZED RESISTOR (IRC TYPE BTS) 5%
4. ALL VARIABLE RESISTORS ± 20% 1/2 W UNLESS OTHERWISE SPECIFIED
5. ARROWS INDICATE CLOCKWISE ROTATION
6. ⊘ DENOTES FACTORY ADJUSTMENT
7. ⊚ DENOTES FRONT PANEL ADJUSTMENT
8. ALL CAPACITOR VALUES MICRO MICRO FARADS (uuf) UNLESS OTHERWISE SPECIFIED
9. ALL CAPACITORS 500V UNLESS OTHERWISE SPECIFIED
10. ALL SWITCH SECTIONS SHOWN IN EXTREME COUNTER CLOCKWISE- POSITION AS VIEWED FROM FRONT PANEL
11. AVERAGE CIRCUIT VOLTAGES SHOWN
12. (SCALE ILLUMINATION) R411 ON A COMMON SHAFT WITH POWER SWITCH S602
13. UNDERLINED CONTROL TITLES INDICATE FRONT PANEL LOCATION

CIRCUIT SCHEMATIC
DU MONT TYPE 304-A
CATHODE - RAY OSCILLOGRAPH
Ref. drwg. 98000114 - 4, Issue 5



CIRCUIT SCHEMATIC

DU MONT TYPE 304-A

CATHODE - RAY OSCILLOGR

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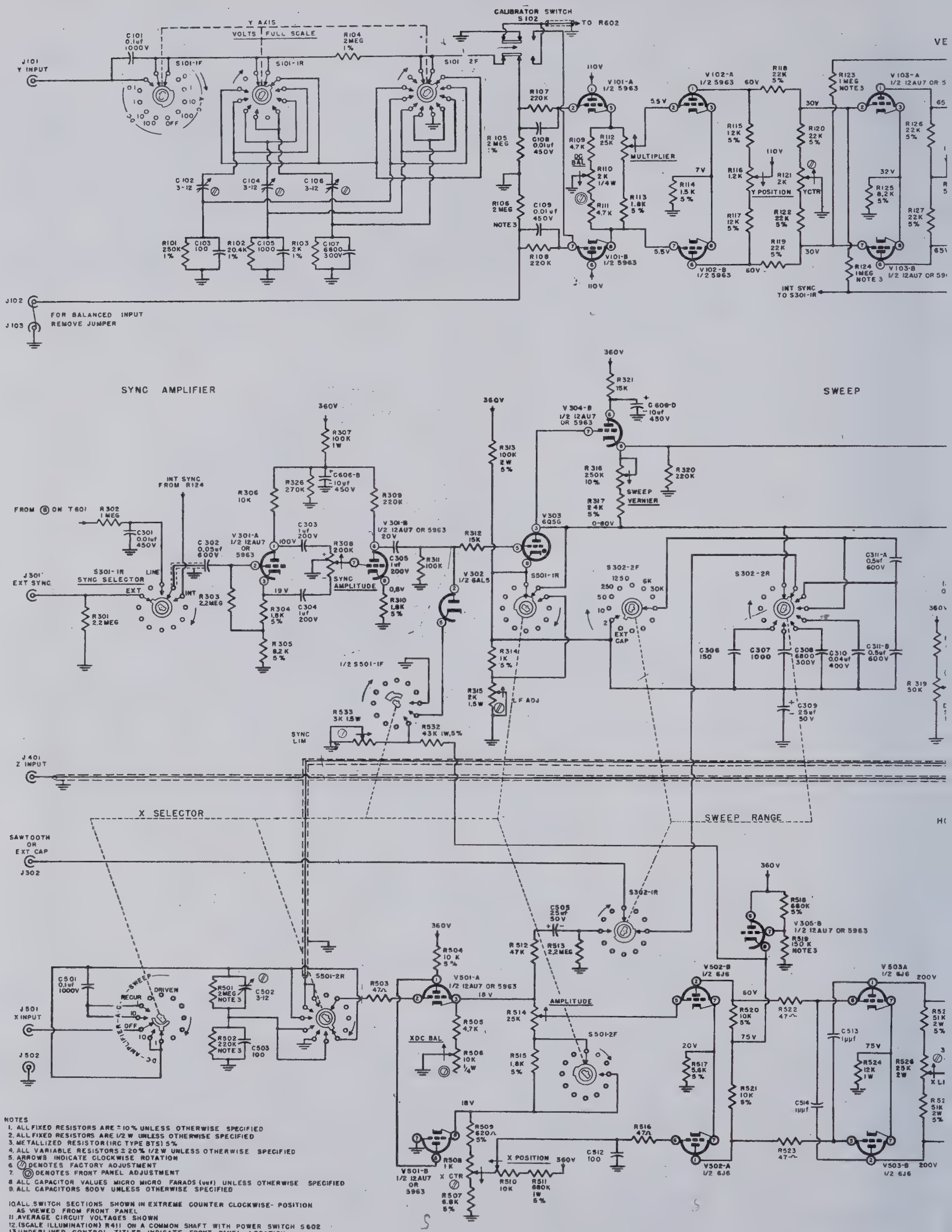
1554E5



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OPERATING AND MAINTENANCE MANUAL

DU MONT

TYPE 304-A
CATHODE-RAY OSCILLOGRAPH

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INSTRUMENT DIVISION
1500 MAIN AVENUE, CLIFTON, N.J., U.S.A.

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Clifton, N. J.
U.S.A.

Part No. 67008863

OPERATING AND MAINTENANCE MANUAL

DU MONT

TYPE 304-A
CATHODE-RAY OSCILLOGRAPH

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Part No. 67008863

SECTION I

GENERAL DESCRIPTION

1. INTRODUCTION

The Du Mont Type 304-A is a general-purpose cathode-ray oscillograph that enables rapid, accurate amplitude measurements of any portion of a 0- to 1000- volt signal, from d-c to over 50,000 cps. The high gain assures that the Type 304-A can be used directly with most transducers, while d-c amplification provides that the lowest frequency portions of signals will be faithfully reproduced.

To obtain the utmost from the Type 304-A, full advantage should be taken of the novel amplitude calibrating system of the instrument which permits signal amplitude measurements in volts directly from the screen. (See "Amplitude Calibration") Unlike electro-mechanical devices, the Type 304-A is not restricted to rms or peak-to-peak readings of voltage, as any amplitude portion of the input signal may be measured with the instrument. Moreover, these measurements may be made in a minimum of time, qualifying the Type 304-A as a quantitative as well as a qualitative instrument.

The Type 5ADP-cathode-ray tube is employed in the Type 304-A. This tube is precision-built to tolerances far more stringent than in conventional tubes, and provides a deflection sensitivity up to twice that of conventional types, as well as a smaller spot size with no sacrifice in brilliance. The Types 304-A and 304-AR differ only in that the Type 304-AR is designed for mounting in a standard, 19-inch relay rack.

2. PHYSICAL CHARACTERISTICS

Physical specifications of both the Type 304-A and the Type 304-AR are given in convenient tabular form in Table 1-1. The Type 304-A is enclosed in a gray metal cabinet complete with a convenient carrying handle. The Type 304-AR employs a standard relay rack panel, a dust cover and a bottom plate. The operating controls of both

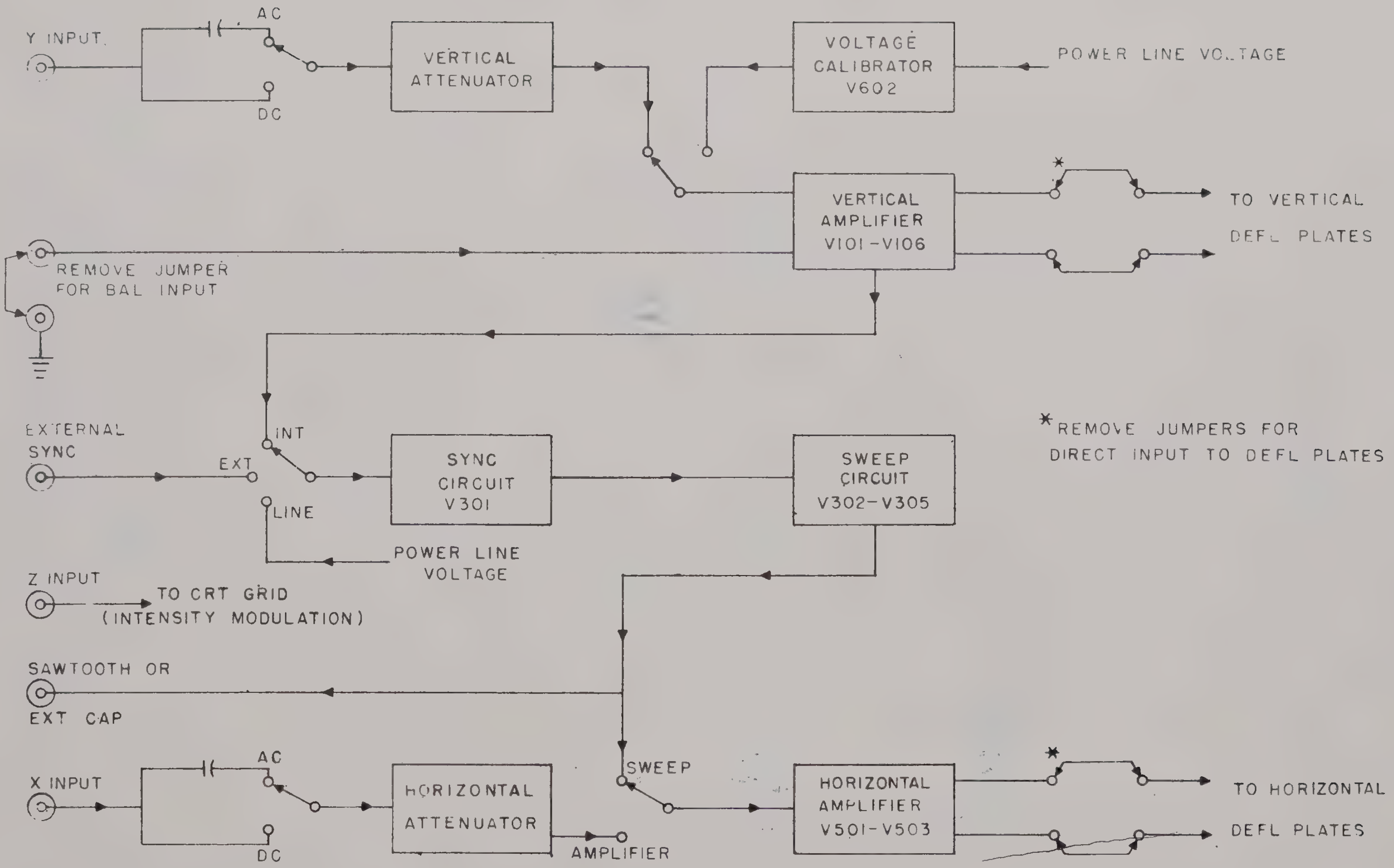


FIGURE 1-2. SIMPLIFIED BLOCK DIAGRAM OF TYPE 304-A

instruments are conveniently located on the front panel with vertical amplifier controls on the left and horizontal sweep controls on the right. In both instruments a convenient terminal panel, accessible at the rear, provides direct access to the deflection plates of the cathode-ray tube.

To facilitate calibration, the scale of the Type 304-A is numbered and edge illuminated, with a dimmer control provided on the front panel. Unidirectional signal amplitudes are measured with the aid of the left-hand scale, symmetrical signals with the aid of scale on the right hand. These scales make it especially convenient to photograph a trace with scale superimposed. The usual double-exposure technique is normally not necessary when employing an instrument with an illuminated scale; thus, valuable time is saved, and more accurate results are obtained. The Type 304-A is also provided with a suitable color filter over the face of the CRT to improve visual contrast.

Provision is made for connection of balanced, as well as single-ended vertical input signals on the 0.1 volt full scale range. Balanced input may be obtained merely by disconnecting a jumper to ground the lower Y-input terminal on the front panel.

Also provided on the front panel is a Z-axis input terminal for intensity modulation. This terminal connects directly to the grid of the cathode-ray tube, with positive signals increasing the intensity of the beam.

3. CIRCUITRY EMPLOYED

For a general understanding of the electrical circuits incorporated in this oscillograph, refer to the block diagram (Figure 1-2). A detailed explanation of the circuit operation will be found in Section III, THEORY OF OPERATION.

A very sensitive vertical amplifier is employed in the Type 304-A. With the amplifier set at full gain an applied AC or DC signal of 0.1 volt peak-to-peak will result in full-scale deflection of the electron beam. Increased stability is assured by regulation of the heaters of the vertical amplifier input stages.

To assist in observing random phenomena or recurrent pulses having relatively low-duty cycles, the sweep circuit may be adjusted, by means of a front-panel control, so that the sweep is initiated by the signal itself (DRIVEN SWEEP). Both driven and recurrent sweeps may be expanded up to six times full-screen diameter with full positioning. To obtain sweeps of extremely long duration provision is made for attaching external capacitances to convenient terminals, 0.5 second sweep being secured for each microfarad of external capacitance employed.

Stabilized synchronization minimizes horizontal jitter of traces, while sync limiting for both driven and recurrent operation prevents spurious or distorted response from excessive synchronizing signals.

For a thorough understanding of the capabilities of the Type 304-A the following sections, OPERATION and THEORY OF OPERATION, should be read carefully.

TABLE 1-1

PERFORMANCE SPECIFICATIONS

CATHODE-RAY TUBE	
Type	5ADP-
Accelerating Potential	Second Anode: +1600 volts Intensifier +3000 volts
Illuminated Scale	Engraved, illuminated scale over face of tube; dimmer control provided on front panel
VERTICAL CHANNEL (Y-AXIS)	
Deflection Factor	
Amplifier (at full gain)	0.1 volt peak-to-peak full scale; or 0.025 peak-to-peak volt/inch. (0.009 rms volt/inch)
Direct	32-39 peak-to-peak volts/inch (12-14 rms volts/inch)
Undistorted Deflection	4 inches (limited by deflection-plate cutoff in the cathode-ray tube) Portions of expanded pattern (Up to 4 times full screen) will also have negligible distortion when positioned on screen
Sinusoidal Frequency Response (Thru Ampl)	
Direct Coupling	Down not more than 10% at 100 kilocycles
Capacitive Coupling	Down not more than 10% from 10 cycles to 100 kilocycles
Either Type Coupling	Down not more than 50% at 300 kilocycles
Transient Response (Thru Ampl)	
Rise Time (10% to 90%)	2 μs or less
Overshoot	None
Sawtooth	
Direct Coupling	No tilt
Capacitive Coupling	10% tilt or less (in 45 milliseconds)

TABLE 1 - 1

PERFORMANCE SPECIFICATIONS (Continued)

Input Voltage (To Ampl) - Maximum	
Single-ended	
Capacitive Coupling	1000 (dc plus peak ac)
Direct Coupling	1000 (dc plus peak ac) on all attenuation ranges except 0.1 V where it is 100 volts (dc plus peak ac)
Balanced	May be operated up to +2 volts with 0.4 volt peak-to-peak between grids (VOLTS FULL SCALE set at 0.1)
Input Coupling (To Ampl)	Capacitive or direct
Attenuation (Ampl Connection)	By factors of 1, 10, 100, or 1000 ±2% as selected by the VOLTS FULL SCALE switch (0.1V, 1V, 10V, or 100V, respectively)
Input Impedance	
Amplifier	
Single-ended	2 megohms, 50 μμf
Balanced	4 megohms, 40 μμf
Direct	
Single-ended	1.5 megohms, 20 μμf
Balanced	3.0 megohms, 20 μμf
Positioning	Permits examination of screen of any portion of signal expanded to four times full-screen diameter
HORIZONTAL CHANNEL (X AXIS)	
Deflection Factor	
Amplifier (at full gain)	0.3 peak-to-peak volt/inch (0.1 rms volt/inch)
Direct	40-50 peak-to-peak volts/inch (15-18 rms volts/inch)
Sinusoidal Frequency Response (Thru Ampl)	
Direct Coupling	Down not more than 10% at 100 kilocycles or 50% at 300 kc
Capacitive Coupling	Down not more than 10% from 10 cycles to 100 kilocycles or 50% at 300 kc
Transient Response (Thru Ampl)	Same as for Vertical (Y-AXIS) Amplifier

TABLE 1-1

PERFORMANCE SPECIFICATIONS (Continued)

Input Voltage (Maximum) to Ampl.	Attenuator Setting — Peak-to-Peak Volts 1:1 — 18 10:1 — 180 Maximum DC with Attenuator in AC position 1000 volts
Input Coupling (To Ampl).	Capacitive or Direct
Attenuation (Ampl Connection).	By factors of 1 or 10 ± 10%, as selected
Input Impedance	
Amplifier.	2.2 megohms, 50 μμf
Direct	
Single-ended	1.5 megohms, 20 μμf
Balanced.	3 megohms, 20 μμf
Linear-sweep Time Base	
Circuit.	Type 6Q5G gas triode, for both driven and recurrent sweeps. Return trace is automatically blanked.
Frequency (Recurrent Sweep)	2 to 30,000 sawtooth cps. Sweep frequencies lower than 2 cps may be obtained by attaching external capacitance between SAWTOOTH/EXT CAP terminal and ground. For each microfarad of external capacitance, approximately 0.5 seconds of sweep time is secured.
Time Duration (Driven Sweep)	0.5 seconds to approximately 30 microseconds.
Expansion.	To 6 times full-screen diameter with no appreciable distortion
Positioning	So any portion of expanded sweep may be examined on screen
Synchronization.	INTernal, EXTernal, or LINE frequency as selected, either polarity
Maximum Photographic Writing Rates (With P-11 screen phosphor).	Du Mont Type 297 (Polaroid-Land) Camera with f/2.8 lens -- 0.08 inch/μs Du Mont Type 296 (35 mm) Camera with f/2.8 lens -- 0.8 inch/μs Du Mont Type 295 (35 mm) Camera with f/1.5 lens -- 2.8 inches/μs Du Mont Type 321 (35 mm moving-film) Camera with f/1.5 lens -- 2.8 inches/μs

TABLE 1-1

PERFORMANCE SPECIFICATIONS (Continued)

INTENSITY MODULATION CIRCUIT (Z AXIS)

Input Impedance	0.2 megohms, 80 μμf
Sensitivity	2.56 volts peak-to-peak (negative) will blank the beam depending on intensity setting
Polarity	Positive signals increase the intensity of the beam

CALIBRATION VOLTAGE

Availability	To input of vertical Ampl. by means of front-panel switch
Waveshape	Square Wave
Frequency	Power Line
Amplitude	0.1 volt peak-to-peak
Accuracy (Amplitude)	±5% or better

SAWTOOTH OUTPUT

Availability	Front-panel terminal
Amplitude	5 volts peak-to-peak
Polarity	Positive
Frequency	2 to 30,000 cps, as selected. Sweep frequencies lower than 2 cps may be obtained by attaching external capacitance between this terminal and ground
Impedance	Approximately 45,000 ohms

POWER SUPPLY

Primary-power Potential	115 or 230 rms volts ±10%
Frequency	50-400 cps
Power Consumption	Approximately 110 watts
Fuse Protection	
115-volt operation	1.5 amperes
230-volt operation	0.75 amperes

TUBE COMPLEMENT

6 - 12AU7	1 - OB2	2 - 1X2A	
2 - 6AQ5	2 - 6J6	2 - 6AL5	1 - (3-14)
1 - 6Q5G	1 - 5Y3GT	2 - 5963	1 - 5ADP-

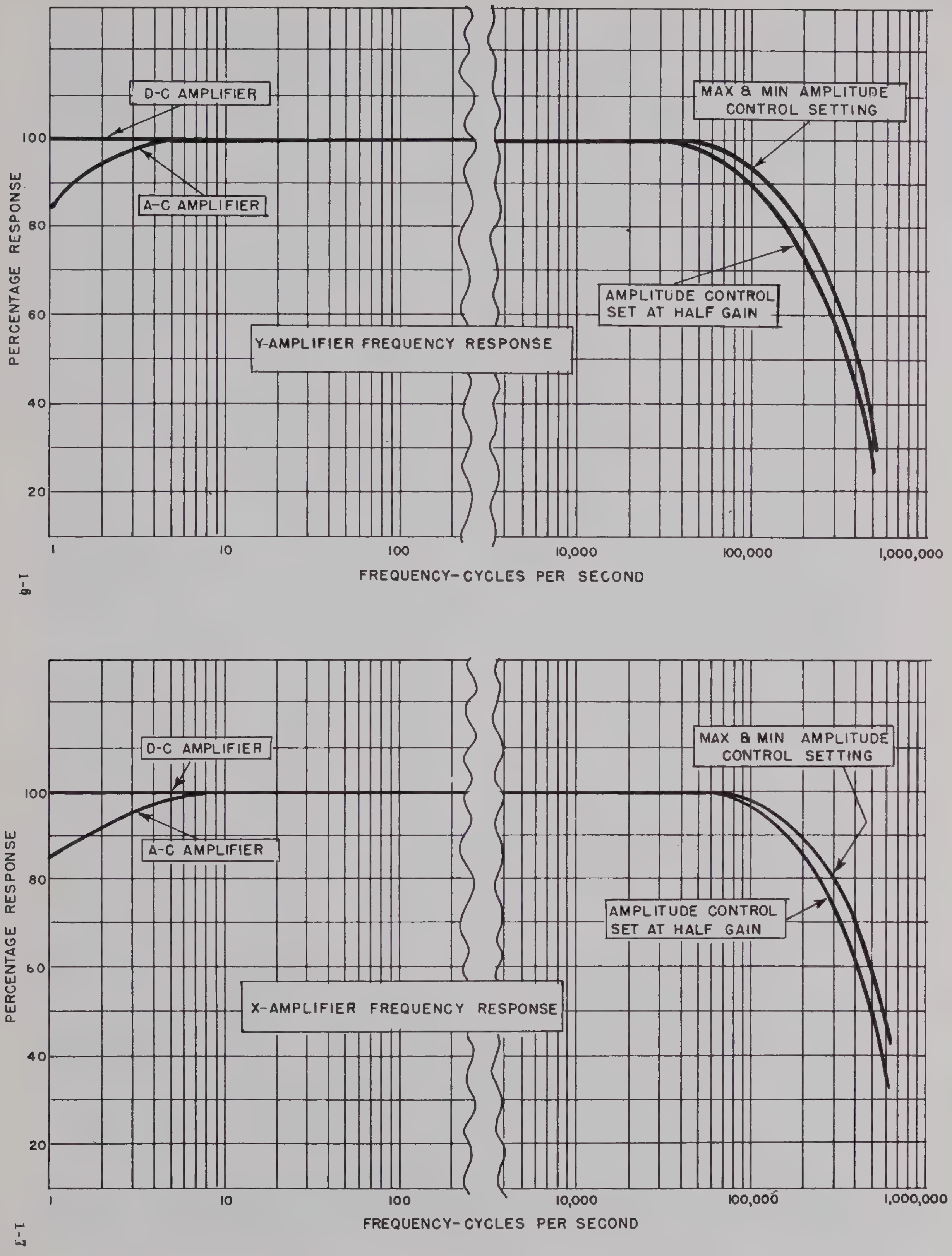


FIGURE 1-3 FREQUENCY RESPONSE CHARACTERISTICS

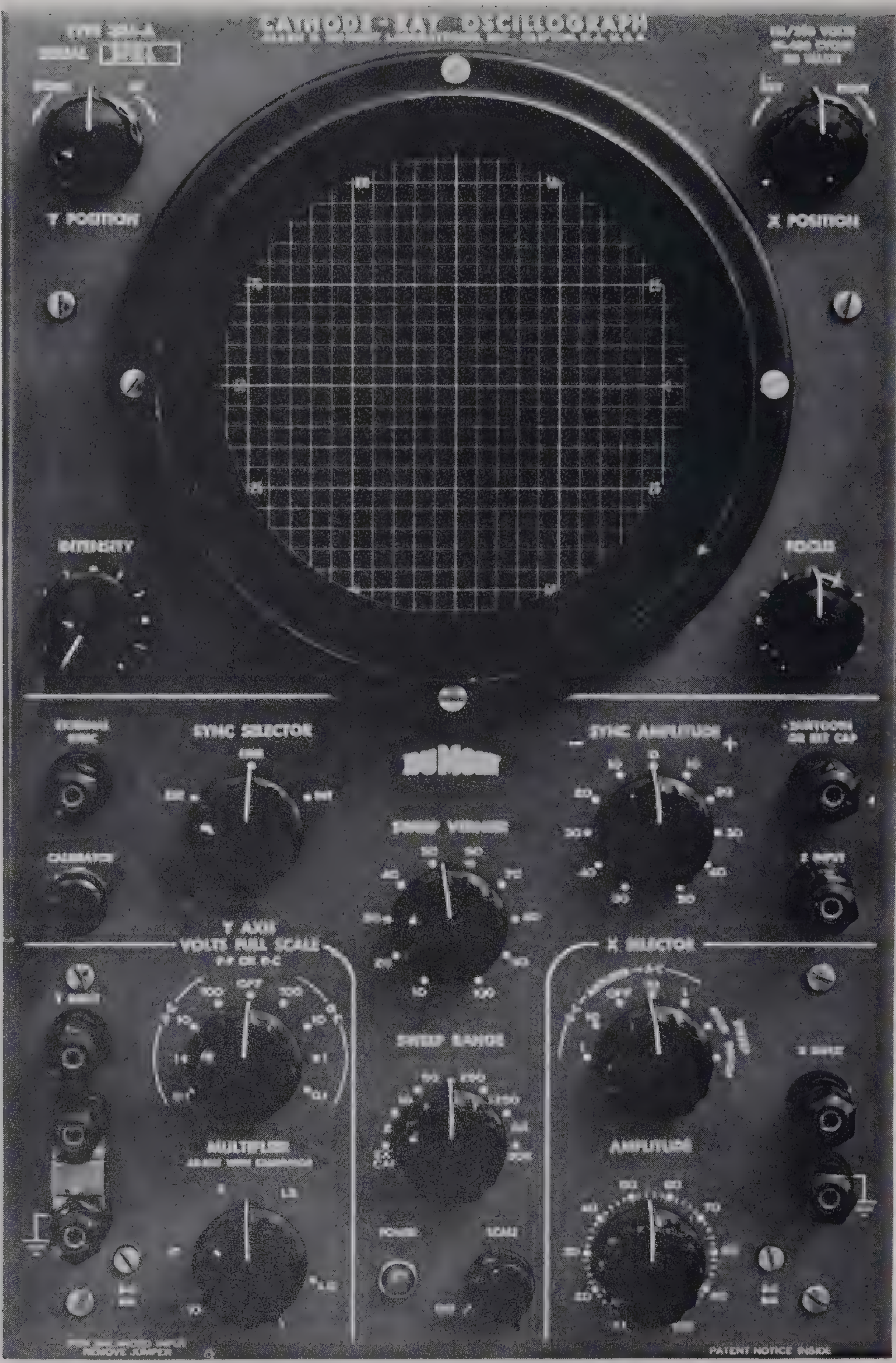


FIGURE 2-1. FRONT PANEL VIEW OF TYPE 304-A

SECTION II

OPERATION

1. UNPACKING AND INSPECTING THE EQUIPMENT

The Du Mont Type 304-A Cathode-ray Oscillograph is shipped with all tubes in place and ready to operate. However, upon receipt, it should be inspected for any apparent damages, such as broken knobs, tubes, or other components. To slide the chassis of the Type 304-A out of its cabinet, remove the two screws at the back of the instrument. To remove the dust cover from the Type 304-AR, loosen the screws on either side and rear that hold the dust cover to the chassis.

2. LOCATION AND INSTALLATION

a. GENERAL

Since the Type 304-A is a portable test instrument, no special installation procedure is required. The Type 304-AR has a front panel 19 inches wide by 8-23/32 inches high for mounting the instrument in a standard relay rack or cabinet.

Normally, the Type 304-A may be placed where most convenient for viewing the screen. It is always desirable to employ the shortest possible signal leads to either instrument to avoid stray pickup.

Although magnetic and electrostatic shielding has been provided in the design of the instrument, operation in strong fields such as are found near transmitters, transformers, and power-generating equipment, etc., may introduce spurious deflections, and should be avoided.

Electrostatic pickup may be minimized by the use of shielded input cables and connections and with a good electrical ground on the chassis of the instrument. Spurious magnetic deflections may be eliminated or reduced to an unobjectionable point by removing the oscillograph from the immediate vicinity of the disturbance; orienting the instrument in the field so that spurious deflection is at a minimum; or in extreme cases, by adding additional magnetic shielding in the form of a large iron or steel container in which the entire instrument may be placed.

b. LINE VOLTAGE AND FREQUENCY

The Types 304-A and 304-AR Cathode-ray Oscillographs are supplied for operation from a 50 to 400-cycle source of power at 115 or 230 volts rms. Unless otherwise specified by the customer when ordering, the instrument is shipped from the factory for operation on 115-volt line. A tag on the handle will specify the proper line voltage. To change from 115-volt to 230-volt line operation or vice versa, see Section IV on Maintenance.

c. POWER REGULATION

The Type 304-A will operate satisfactorily with steady line-voltage variations of ±10% from the specified value, due to the regulator circuits employed in the instrument. However, greater than 10 per cent variation may cause the power supply to operate erratically with consequent unsatisfactory performance of the oscillograph. Where line-voltage variations are excessive, it is recommended that a constant-voltage transformer be employed in the power line to the instrument. If such a regulator is used, precautions should be taken to avoid the effects of stray magnetic fields as discussed in paragraph 2a above.

- WARNING -

Potentials as high as 3000 volts are employed in this instrument. Such voltages are extremely dangerous; and every possible safety precaution should be taken to avoid contact with this potential. The instrument is safe when enclosed in its cabinet and should not be operated with the chassis withdrawn except for purposes of adjustment or repair. When necessary to energize the oscillograph with the chassis outside its cabinet, refer to the precautions given in paragraph 2 of Section IV, Maintenance.

3. TURNING ON THE INSTRUMENT

A dual function power switch and scale illumination control is provided; the front panel designation is SCALE. To place the instrument in operation, plug the power cord into the line outlet, and turn on the power switch. Allow approximately 30 seconds for the instrument to warm up; in the meantime, set the various controls as indicated in Table 2-1.

4. PRECAUTION AGAINST SCREEN BURNING

A sharply focused line or spot of high intensity, having short length or small area, respectively, should not be permitted to remain stationary on the screen for any considerable length of time. Under such conditions, the entire energy of the beam is concentrated over a small area, thus subjecting the screen material to burning and discoloration.

5. CONTROLS AND TERMINALS

a. GENERAL

The markings on the front panel adjacent to each control (See Figure 2-1) are essentially self-explanatory, and the operator should find it possible to master the controls with a minimum of experimentation.

b. CONTROL AND TERMINAL FUNCTIONS

Table 2-2 lists all front-panel controls and terminals and gives the function of each. Also, specific problems, which may be encountered in operating the instrument, are explained in this table.

TABLE 2 - 1

PRELIMINARY SETTING OF CONTROLS

CONTROL	POSITION
Y POSITION	center of range
X POSITION	center of range
INTENSITY	fully counterclockwise
FOCUS	center of range
SYNC SELECTOR	INTernal
SYNC AMPLITUDE	"O"
X SELECTOR	RECURrent SWEEP
Y AXIS VOLTS FULL SCALE	OFF
MULTIPLIER	fully counterclockwise
(X) AMPLITUDE	fully counterclockwise
SWEEP VERNIER	center of range
SWEEP RANGE	50-250
CALIBRATOR push button	released (out)

TABLE 2 - 2

TABLE OF OPERATING CONTROLS AND TERMINALS

Name of Control or Terminal	Reference Symbol	Function
	*FRONT PANEL CONTROLS	
INTENSITY	R407	Changes the intensity of the trace.
FOCUS	R405	Adjusts focus of the trace.
Y POSITION	R116	Changes the vertical position of the trace.
X POSITION	R510	Changes the horizontal position of the trace.
D-C BAL (Y AXIS)	R110	When properly adjusted, prevents change in the vertical position of the trace when the MULTIPLIER control is varied.
D-C BAL (X AXIS)	R506	When properly adjusted, prevents change in the horizontal position of the trace when the (X) AMPLITUDE control is varied.
Y AXIS VOLTS FULL SCALE	S101	Provides for the direct peak-to-peak reading of the input signal in steps 0.1V, IV, 10V and 100V for both a-c and a-d inputs. OFF position also provided.
MULTIPLIER	R112	Controls amplitude of the vertical deflection.
X SELECTOR	S501	Selects internal or external signal for the horizontal deflection. The internal signal is linear sawtooth sweep, either recurrent or driven. On external signals, either d-c or a-c coupling at attenuation ratios of 1 or 10 is provided. OFF position also provided.
(X) AMPLITUDE	R514	Controls the amplitude of horizontal deflection
SWEEP RANGE	S302	Varies sweep frequency in steps.
SWEEP VERNIER	R316	Provides continuous variation of sweep frequency when used in conjunction with SWEEP RANGE.
SYNC SELECTOR	S301	Selects synchronizing signals, internal line-frequency, or external.
SYNC AMPLITUDE	R308	Selects phase and varies amplitude of sync voltage.
CALIBRATOR	S102	When pushed in, provides calibrating voltage to check setting of MULTIPLIER.
SCALE	R411	Varies the illumination intensity of the illuminated scale. Switch attached provides means for turning power on and off.

TABLE 2-2

TABLE OF OPERATING CONTROLS AND TERMINALS (Continued)

Name of Control of Terminal	Reference Symbol	Function
FRONT PANEL TERMINALS		
EXTERNAL SYNC	J301	Provides for connection of external sync signals when the SYNC SELECTOR is at EXT.
Y INPUT	J101 J102 J103	Provides for the connection of external signals to the Y amplifier. A jumper is provided for conventional single-ended input. Remove jumper for balanced input (no attenuation).
X INPUT	J501 J502	Provides for connection of external signals to the X amplifier.
SAWTOOTH or EXT CAP	J302	Provides for sweep sawtooth voltage at front panel. Also provides for connection of an external capacitor for low-frequency sweeps. Sawtooth output is available only when X SELECTOR is set at SWEEP.
Z INPUT	J401	Provides for connection of external signals to intensity modulate the trace.
**BACK-OF-PANEL TERMINALS (Accessible at Rear of Cabinet or Dust Cover)		
DEFLECTION PLATE INPUT TERMINALS "UP" and "DOWN"	J107 J111	Provides for connection of signals to vertical deflection plates direct (through capacitor).
DEFLECTION PLATE INPUT TERMINALS "RIGHT" and "LEFT"	J506 J510	Provides for connection of signals to horizontal deflection plates direct (through capacitor).
Y-AXIS	J104 J105 J106 J108 J109 J110	Provides "Direct" or "Through Amplifier" connection of vertical deflection voltages.
X AXIS	J503 J504 J505 J507 J508 J509	Provides for "Direct" or "Through Amplifier" connection of horizontal deflection voltages.

*Refer to Figure 2-1 for identification of front-panel controls.

**See Figure 2-3 for identification of deflection-plate input terminals.

c. SYNCHRONIZATION OF SWEEP

(1) RECURRENT SWEEP

As a general rule, it is desirable to set the SYNC SELECTOR switch at INTernal. Thus, low-amplitude signals applied to the Y INPUT are amplified sufficiently before application to the sync circuits to produce stable synchronization of the sweep generators. Provision is also made for EXTernal sync, which is useful particularly in those cases where varying amplitudes of the same waveform are to be viewed in rapid succession. LINE-frequency sync is provided particularly as a convenience in synchronizing line-frequency signals applied direct to the deflection plates, in noting phase shifts of line-frequency signals with respect to the power line and as an aid in synchronizing line-frequency signals of low-amplitude or having a high noise content.

The proper manner of sync adjustment is as follows:

(a) Set the X SELECTOR at RECUR SWEEP.

(b) Set the SYNC SELECTOR at EXT, INT or LINE depending upon the signal to be synchronized as discussed above.

(c) Set the SYNC AMPLITUDE control at "O".

(d) Adjust the SWEEP RANGE and SWEEP VERNIER controls to obtain the desired number of cycles of the signal on the screen and to stop the travel of the pattern as nearly as possible.

(e) Rotate the SYNC AMPLITUDE control either clockwise or counterclockwise to lock the pattern stationary, depending upon whether it is desired to have the beginning of the trace positive going or negative going, respectively.

(2) DRIVEN SWEEP

The DRIVEN SWEEP mode generally is employed for viewing random or aperiodic signals or periodic signals having a low-duty cycle. When operating the instrument in this manner, one cycle excursion of the sweep occurs for each signal impulse or multiple thereof. To operate in this mode, proceed as follows:

(a) USING INTERNAL SYNC

1. Set SYNC SELECTOR at INT, SYNC AMPLITUDE at "O", X SELECTOR at OFF, and advance the (X) AMPLITUDE control approximately 1/4 turn. If necessary, position the beam to center of screen.

2. Apply signal to be observed to Y INPUT terminals, and adjust the VOLTS FULL SCALE and MULTIPLIER controls for approximately 1-1/2 inch vertical deflection.

3. Place the X SELECTOR in DRIVEN SWEEP position, and rotate the SYNC AMPLITUDE control until a steady sweep is observed. The setting the SYNC AMPLITUDE control may be critical.

4. Adjust SWEEP RANGE and SWEEP VERNIER controls until, with periodic input signals, a steady pattern with the desired number of cycles is obtained; or, with aperiodic or low-duty cycle signals, the complete waveform appears on the sweep.

5. Adjust the X POSITION and (X) AMPLITUDE controls, if necessary, to obtain the desired portion of the trace on screen.

(b) USING EXTERNAL SYNC

When very high-frequency signals are to be observed, it may be helpful to resort to EXTernal sync to avoid erratic triggering of the sweeps. For EXTernal sync operation, proceed as follows:

1. Set SYNC SELECTOR at EXT and all other controls as described under "Using Internal Sync", paragraph 5c (2a).

2. Apply the EXTernal sync signal by connecting a test lead between the Y INPUT and EXTERNAL SYNC front-panel terminals; or, for most effective triggering from non-sinusoidal signals, apply the sync signal through a differentiating network having a time constant of approximately 10 per cent of the period of the sync employed. For details of the differentiating circuit, see Figure 2-2.

d. OBTAINING LOW-FREQUENCY SWEEPS

Provision is made for connecting external capacitors to the SAWTOOTH or EXT CAP terminal on the front panel to obtain lower frequency sweeps than provided for in the instrument. The lowest sweep frequency obtainable without resorting to external capacitors is two cycles per second. For lower frequency sweeps, proceed as follows:

1. Set the SWEEP RANGE switch to EXT CAP, and position the SWEEP VERNIER control fully counterclockwise.

2. Connect an external capacitor as determined from Table 2 - 3 between the SAWTOOTH or EXT CAP and ground terminals. Depending upon the value of capacitance chosen, the sweep frequency will be approximately as shown in the table. The SWEEP VERNIER may be employed to vary the sweep frequency over a limited range.

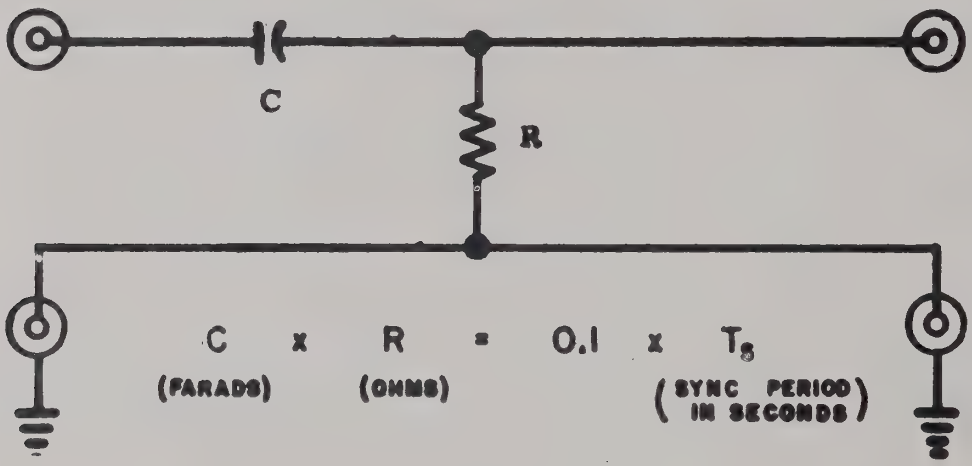


FIGURE 2 - 2. DIFFERENTIATING CIRCUIT FOR USE IN ESTABLISHING STABLE DRIVEN SWEEP

TABLE 2-3

EXTERNAL CAPACITORS FOR LOW-FREQUENCY SWEEPS

Sweep Frequency	Sweep Duration	External Capacitance Required*
1cps	1 second	2$\mu\mu$f
0.5cps	2 seconds	4$\mu\mu$f
0.25	4 seconds	8$\mu\mu$f
0.1	10 seconds	20$\mu\mu$f

*A high-leakage resistance capacitor must be employed such as a paper or plastic dielectric type. A 20 μf capacitor is the highest value recommended. Too large a capacitor tends to produce a distorted sawtooth waveform.

e. AMPLITUDE CALIBRATION

The calibrated VOLTS FULL SCALE attenuator switch and MULTIPLIER control provides a ready means for determining peak-to-peak input-signal amplitude for both a-c and d-c inputs. The product of the dial readings (VOLTS FULL SCALE and MULTIPLIER) gives the approximate peak-to-peak voltage for four inches of deflection.

For rough measurement of input signal voltage, proceed as follows:

(1) With input signal applied, adjust the VOLTS FULL SCALE switch and MULTIPLIER control to produce a convenient vertical deflection.

(2) Multiply the product of the readings of these controls by the vertical deflection produced (in inches) and divide by four to obtain the input signal amplitude (in peak-to-peak volts).

For most accurate measurements, a square-wave calibrating voltage is provided for accurate setting of the MULTIPLIER control. The procedure is as follows:

(1) With no signal applied to the Y INPUT terminals, set the front-panel controls according to the following table:

CONTROL	POSITION
MULTIPLIER	At position where accurate calibration is desired
X SELECTOR	RECUR SWEEP
SWEEP RANGE	50 - 250
SYNC SELECTOR	LINE
Y POSITION	So trace is centered on screen

(2) Push in the CALIBRATOR switch and adjust the SWEEP VERNIER and SYNC AMPLITUDE controls for several square-wave cycles or a band on the cathode-ray screen.

(3) Referring to the Calibration Chart, Table 2-4, determine the deflection to be observed at the particular setting of the MULTIPLIER control. If necessary, vary the screwdriver adjustment, accessible through the small hole at the left side of the cabinet, to produce proper deflection. The MULTIPLIER control is thus accurately calibrated at this one position only. The multiplier may be adjusted to produce the deflection required so that the sensitivity is accurate.

(4) Apply Y INPUT signal and note beam deflection produced.

(5) Multiply signal deflection (in inches) by the sensitivity in volts per inch obtained from Table 2-5, making certain to pick the sensitivity corresponding to the VOLTS FULL SCALE switch position employed. The resulting figure is the signal amplitude in volts. Note: For accurate calibration of input signals higher than 50 kc. an external calibrator at the same frequency as the input signal should be employed.

TABLE 2-4

CALIBRATION CHART

--VERTICAL DEFLECTION VS POSITION OF "MULTIPLIER" CONTROL--

"MULTIPLIER" POSITION	1.0	1.5	2	4	10
DEFLECTION - INCHES -	4.0	2.7	2.0	1.0	0.4

TABLE 2-5

VERTICAL CHANNEL SENSITIVITY
AT VARIOUS SETTINGS OF "VOLTS FULL SCALE" AND
"MULTIPLIER" CONTROLS*

		"MULTIPLIER" POSITION				
		1.0	1.5	2	4	10
"VOLTS FULL SCALE" POSITION	0.1	0.1V 0.025V	0.15V 0.0375V	0.2V 0.05V	0.4V 0.1V	1V 0.25V
	1	1V 0.25V	1.5V 0.375V	2V 0.5V	4V 1V	10V 2.5V
	10	10V 2.5V	15V 3.75V	20V 5V	40V 10V	100V 25V
	100	100V 24V	150V 37.5V	200V 50V	400V 100V	1000V 250V

* *Figures above / line are peak-to-peak volts full scale (4 inches vertical deflection)*
Figures below / line are peak-to-peak volts per inch of vertical deflection

f. INTENSITY MODULATION

The Z INPUT terminal on the front panel provides the facility for brightening or blanking the beam on the screen. Positive-going signals brighten the beam while negative-going signals blank it. An appropriate negative signal applied between the Z INPUT terminal and ground will blank a beam of normal intensity if the signal amplitude is from 34 to 56 volts peak.

g. DIRECT CONNECTION TO DEFLECTION PLATES

(1) GENERAL

When applying signals direct to deflection plates, the highest-frequency signal that can be observed is not limited by the response of the built-in amplifiers but is dependent only upon the input capacity to the deflection plate terminals and/or transit time of the electrons between the deflection plates. Provided the impedance of the signal source is kept low, transit time is the only consideration. It should be remembered, however, that no amplification or attenuation is provided on "direct input" and that approximately 15 rms volts are required to produce an inch of beam deflection.

(2) MAKING PROPER CONNECTIONS

CAUTION

Turn Power Off before making any connections to the rear terminal board Some of these terminals are at approximately 200 volts d-c above ground.

Figure 2-3 shows the location and identification of the terminals provided for making direct connection to the deflection plates. To make connections, follow the instructions given on the terminal board. It will be necessary to move the jumpers from the "through amplifier" position to the "deflection plates" position as indicated and to connect the signal to be observed to the appropriate UP, DOWN, LEFT or RIGHT terminals. The designations, UP, DOWN, LEFT and RIGHT denote for each terminal the direction of deflection resulting from the application thereto of a positive-going signal.

To avoid any possibility of cross-coupling effects, it is suggested that, when connecting a signal direct to deflection plates, the corresponding channel (VOLTS FULL SCALE and/or X SELECTOR) controls be switched to OFF.

(a) SINGLE-ENDED INPUT

For single-ended input, connect a jumper between UP or DOWN terminal and ground (vertical deflection plates) depending on whether a negative-or positive-going signal, applied to the ungrounded terminal, is to deflect the beam up or down, respectively. Connect the signal between the ungrounded terminal (UP or DOWN) and GROUND. In a similar manner, the horizontal deflection plates (RIGHT or LEFT) may be connected for single-ended input.

(b) BALANCED INPUT

For balanced input signals, connect the signal between the terminals designated UP and DOWN (vertical deflection plates) and/or between the terminals designated RIGHT and LEFT (horizontal deflection plates).

(c) POSITIONING

Beam positioning may be obtained by means of the appropriate POSITIONING controls on the front panel in the same manner as when employing the "amplifier" connection

(d) RESTORING THE INSTRUMENT TO NORMAL "AMPLIFIER" OPERATION

When restoring the instrument to normal "amplifier" operation, remove the signal from the DEFLECTION-PLATE INPUT TERMINALS. Replace the jumpers as indicated in the instructions on the terminal board, and apply the signal to the front-panel terminals.

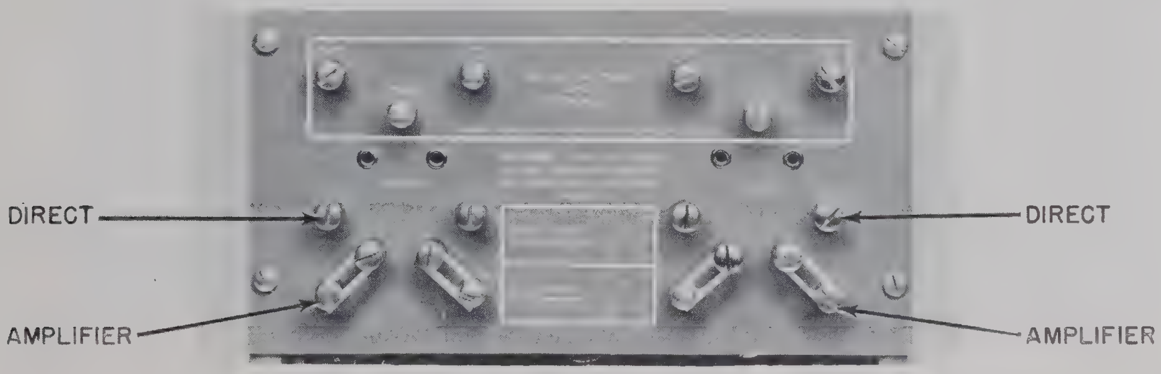


FIGURE 2-3. REAR PANEL VIEW OF TYPE 304-A

6. PHOTOGRAPHING OSCILLOGRAMS

Permanent photographic records of oscillograms, with or without the superposition of the calibrated scale, are readily obtainable from the Type 304-A. Since the calibrated scale may be illuminated, the oscillogram and scale can generally be photographed simultaneously.

Du Mont manufactures several oscillograph-record cameras, both still and moving-film types, specifically designed for effective photorecording. Information on these cameras as well as techniques of recording is available upon request.

7. USE OF BALANCED INPUT

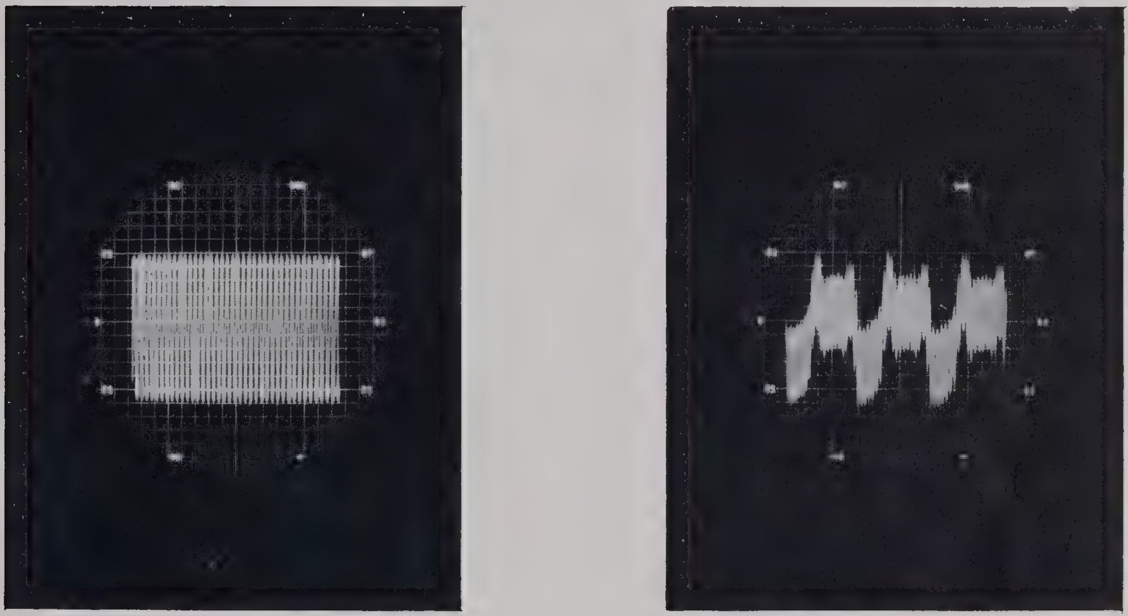
By removing the jumper between one of the Y INPUT terminals and ground, it is possible to feed a balanced-input signal to the vertical (Y-AXIS) amplifier. No attenuation is provided on balanced input; however, the operator may find this feature extremely convenient for various applications. The following explanation of the balanced-input feature may help the operator to determine when this type of operation may be useful or desirable.

If there is an in-phase signal applied to both inputs (known as a "common-mode" signal) superimposed on the balanced-input signal, the maximum input signal (d-c plus peak signal a-c) will be accordingly reduced.

One of the features of the balanced-input circuit is the differential action of the first stage in the Y amplifier. This circuit makes it possible to reject to a considerable degree any common-mode signal while at the same time passing and amplifying the balanced-input signal. Thus, if there is any pickup of noise on test leads or in the equipment under test, such noise will be reduced materially on passing through the balanced-input circuit of the Type 304-A. The waveforms shown in Figure 2-4 illustrate the advantage of the balanced-input connection over the single-ended in such cases. In this figure, a test signal, on which a "nuisance" signal is superimposed is shown on the cathode-ray tube screen when the signal is applied to the balanced input of the Type 304-A. Then, the same signal with the same "nuisance" voltage riding on it, is passed through a network to convert it to unbalanced output and is applied to the unbalanced-input connections of the Type 304-A. Note how much greater the amplitude of the common-mode signal appears with the unbalanced-input connection.

To adjust for the best rejection of the unwanted common-mode signal, remove the jumper from the Y INPUT terminal. Feed a one-volt 60 cycle square-wave signal between both the Y INPUT terminals and ground. Set VOLTS FULL SCALE (D-C) switch at 0.1 and the MULTIPLIER control fully clockwise. Note the beam deflection produced. Vary the MULTIPLIER control for minimum deflection. If this does not reduce the amplitude of the trace to zero, set the MULTIPLIER control approximately midway, and vary the (Y) D-C BAL front-panel screwdriver adjustment for minimum deflection. (It will be necessary to adjust the Y POSITION control as the (Y) D-C BAL adjustment is being made to keep the beam centered vertically on the screen). As now adjusted, it should be possible to go through the common-mode null with either MULTIPLIER control or the (Y) D-C BAL adjustment.

NOTE: OBSERVATION OF SINGLE-ENDED SIGNALS, AFTER HAVING MADE THESE BALANCED-INPUT ADJUSTMENTS, WILL REQUIRE RESETTING OF THE D-C BAL AND Y POSITION CONTROLS.



(a) Test Signal Applied to Balanced Input

(b) Test Signal Applied to Unbalanced Input

FIGURE 2-4. ILLUSTRATING EFFECTIVENESS OF BALANCED INPUT IN ELIMINATING "COMMON-MODE" SIGNALS

SECTION III

THEORY OF OPERATION

1. GENERAL

In following the theory discussion, it is suggested that the simplified block diagram of the Type 304-A (Section I) and the over-all circuit schematic (just inside the back cover of the manual) be referred to in addition to the simplified and unit schematic in this section.

2. CATHODE-RAY TUBE CIRCUIT

a. GENERAL

A simplified schematic of the cathode-ray tube circuit is shown in Figure 3-1. A Type 5ADP- (V401) is employed, operating at a total accelerating potential of 3000 volts, with the intensifier +1600 volts above and the cathode -1400 volts below chassis ground.

b. INTENSITY

First anode and cathode potentials for the cathode-ray tube are obtained from the voltage divider (R403 through R407). The intensity of the beam is adjusted by varying the INTENSITY control (R407). This control varies the cathode potential more or less positive with respect to the grid, which is held at a fixed negative potential.

c. FOCUS

Focusing of the beam for maximum "sharpness" of trace is accomplished by adjusting the FOCUS control (R405). The setting of this control establishes the relative potential difference between anodes (A1) and (A2). The vertical deflection plates (D3 and D4) and the horizontal deflection plates (D1 and D2) operate at an average d-c potential of approximately 200 volts above ground. To avoid beam distortion, the second anode (A2) must operate at approximately the same d-c potential. The second anode voltage is obtained from the arm of potentiometer R409.

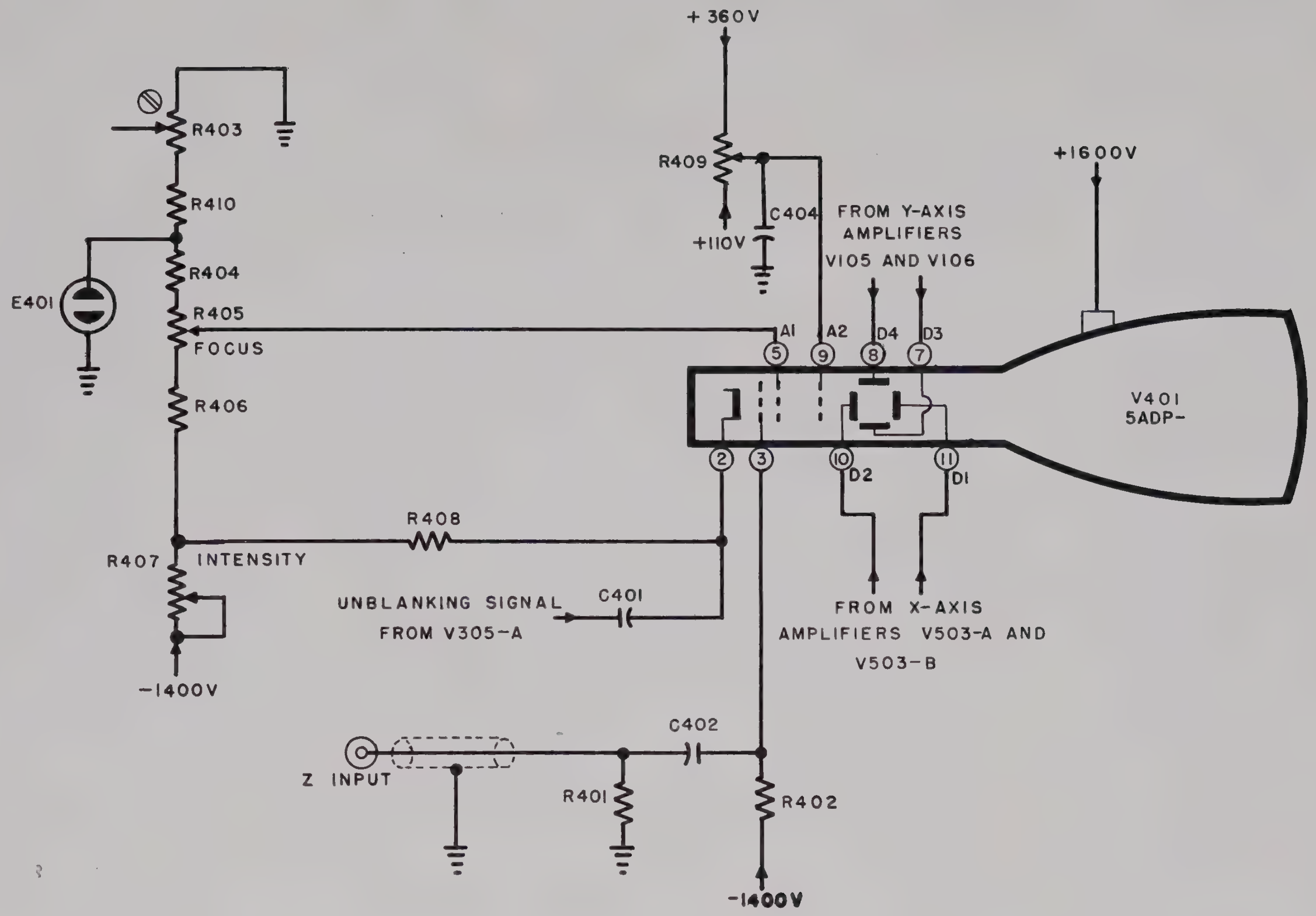


FIGURE 3 - 1. CATHODE-RAY TUBE CIRCUIT (SIMPLIFIED SCHEMATIC)

d. INTENSITY MODULATION

For the purpose of intensity modulation of the beam traces, positive (unblanking) or negative (blanking) signals may be applied from the Z INPUT terminals through coupling capacitor C402 to the grid of the cathode-ray tube.

3. VERTICAL DEFLECTION CIRCUIT (Y AXIS)

a. GENERAL

To facilitate circuit analysis, the vertical-deflection circuit may be considered as consisting of: (1) a frequency-compensated attenuator; (2) a voltage calibrator for determining input-signal amplitudes and (3) a high-gain, wide-band vertical (Y-axis) amplifier for increasing the amplitude of low-level signals for suitable display on the cathode-ray tube screen.

b. INPUT ATTENUATOR

A simplified schematic of the input attenuator (calibrated in peak-to-peak volts full scale) is shown in Figure 3 - 2. The decade attenuators are R-C compensated to maintain frequency and phase response and to present an impedance of 2.0 megohms in shunt with 50 μμf to the circuit under test irrespective of the attenuation selected. The VOLTS FULL SCALE attenuator switch (S101) provides for attenuation of the input signal in decade steps of 1, 10, 100, 1000, for both a-c and d-c inputs. The OFF position of this switch removes the input signal from the attenuator and grounds the grid (pin 2) of the cathode follower (V101). Markings on the front panel for the various switch positions designate full scale sensitivity in volts when the MULTIPLIER (gain) control is set at "1".

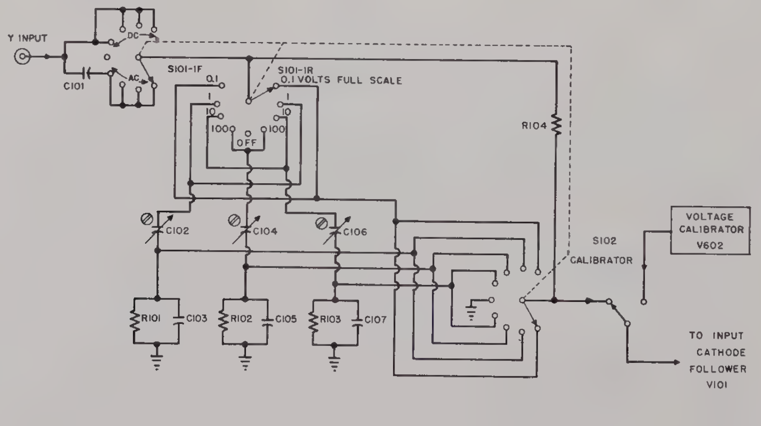


FIGURE 3-2. INPUT ATTENUATOR--VERTICAL CHANNEL (SIMPLIFIED SCHEMATIC)

c. VOLTAGE CALIBRATOR

(1) GENERAL

The location of the voltage calibrator in the vertical deflection circuit is shown by a block on the input attenuator schematic, Figure 3-2. A simplified schematic of the calibrator circuit is shown in Figure 3-3.

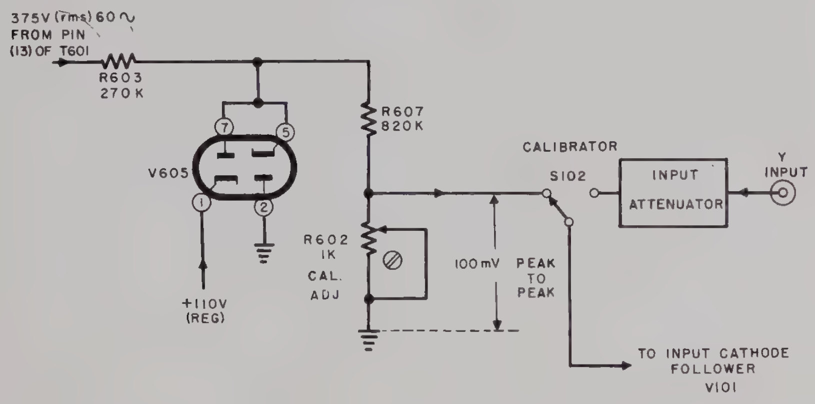


FIGURE 3 - 3. VOLTAGE CALIBRATOR CIRCUIT (SIMPLIFIED SCHEMATIC)

A reference potential of 0.1 volt (100 mv) peak-to-peak is fed to the input cathode follower by the CALIBRATOR switch (S102). For details on making accurate amplitude measurements of the input signal, refer to the instructions contained in paragraph 5e, (Section #II), Operation.

(2) CIRCUIT DESCRIPTION

Referring to Figure 3-3, the 60-cycle voltage from the 375-volt winding on T601 is applied to V602 through limiting resistor R603. On the positive half cycle the voltage build-up across the divider (R607 and R602) is limited to slightly greater than +110 volts peak due to conduction through V602 from cathode (pin 1) to plate (pin 7). The other half of V602 conducts on the negative half cycle thus clamping the top of R607 to essentially ground potential during this time. The result is a 60-cycle square-wave voltage of approximately +110 volts peak-to-peak amplitude appearing across the divider network (R607 and R602). The attenuated output potential is coupled from the junction of R607 and R602 to the CALIBRATOR switch (S102). R602 (CALIBRATOR ADJ) provides a means of varying the calibration voltage to provide exactly 0.1 volt (100 mv) peak-to-peak.

d. VERTICAL (Y-AXIS) AMPLIFIER

(1) INPUT CATHODE FOLLOWER

The circuit of the vertical amplifier is shown in Figure 3-4. V101 is connected as a cathode follower (which on balanced inputs acts effectively as a differential amplifier) and precedes the continuously variable MULTIPLIER (amplitude) control (R112). R113, in series with this control, prevents the operator from cutting the gain all the way to zero. Thus, any signal large enough to saturate the input stage will cause greater than full-screen deflection and can be observed only after the attenuator control(VOLTS FULL SCALE) is set at a higher voltage position or if the amplitude of the applied signal is reduced. This feature prevents inadvertent introduction of distortion into the signal from circuit action within the oscillograph. The normally grounded (pin 7) grid of V101 is brought out to the front-panel jack J102 so that balanced input operation may be obtained simply by removing the jumper between J102 and J103 (front-panel terminals). The resistors (R107 and R108 in series with the grids of V101 serve to protect the input circuit from damage due to excessive input voltage. Shunting capacitors C108 and C109 provide frequency compensation.

The D-C Balance adjustment (D-C BAL), R110, equalizes the voltage at the ends of the MULTIPLIER (amplitude) control. When this adjustment is properly set, there will be no shifting (up and down) of the trace on moving the MULTIPLIER control from minimum to maximum with no input signal to the amplifier.

(2) PUSH-PULL AMPLIFIERS

The vertical deflection amplifiers comprise V102 through V106, inclusive. The d-c balanced circuit agreement of the tubes provides good deflection amplifier stability. The first push-pull amplifier (V102) is preceded by the MULTIPLIER control which varies the amplitude of the input signal after passing through V101.

With the Y POSITION control (R116) set at its mechanical center, the Y CTR back-of-panel control (R131) is normally adjusted to equalize the voltage drops across load resistors R115 and R117 so that the beam trace will be in the vertical center of the cathode-ray tube. The positioning system provided is such that even with a vertical deflection equivalent to four times full-screen diameter, any 5-inch portion of the 20-Y SEN back-of-panel adjustment (R128) is used to set the sensitivity of the Y-deflection system to 9 millivolts rms per inch through the amplifier. This control provides a variable partial short between the plates of the second push-pull amplifier, V103, and the input to the third push-pull amplifier V104.

Voltage for the screen grids of V105 and V106 in the last push-pull stage is obtained from an unregulated supply source to allow the sensitivity of the circuit to rise with increased line voltage. This is designed to compensate for the reduction in the sensitivity of the cathode-ray tube caused by increased accelerating potentials resulting from the increased line voltage. Hence, variation in over-all sensitivity due to line-voltage fluctuations is minimized. The Y LIN back-of-panel control (R136) is a variable screen-dropping resistor for the output tubes (V105 and V106) thus controlling the linearity of the output signal.

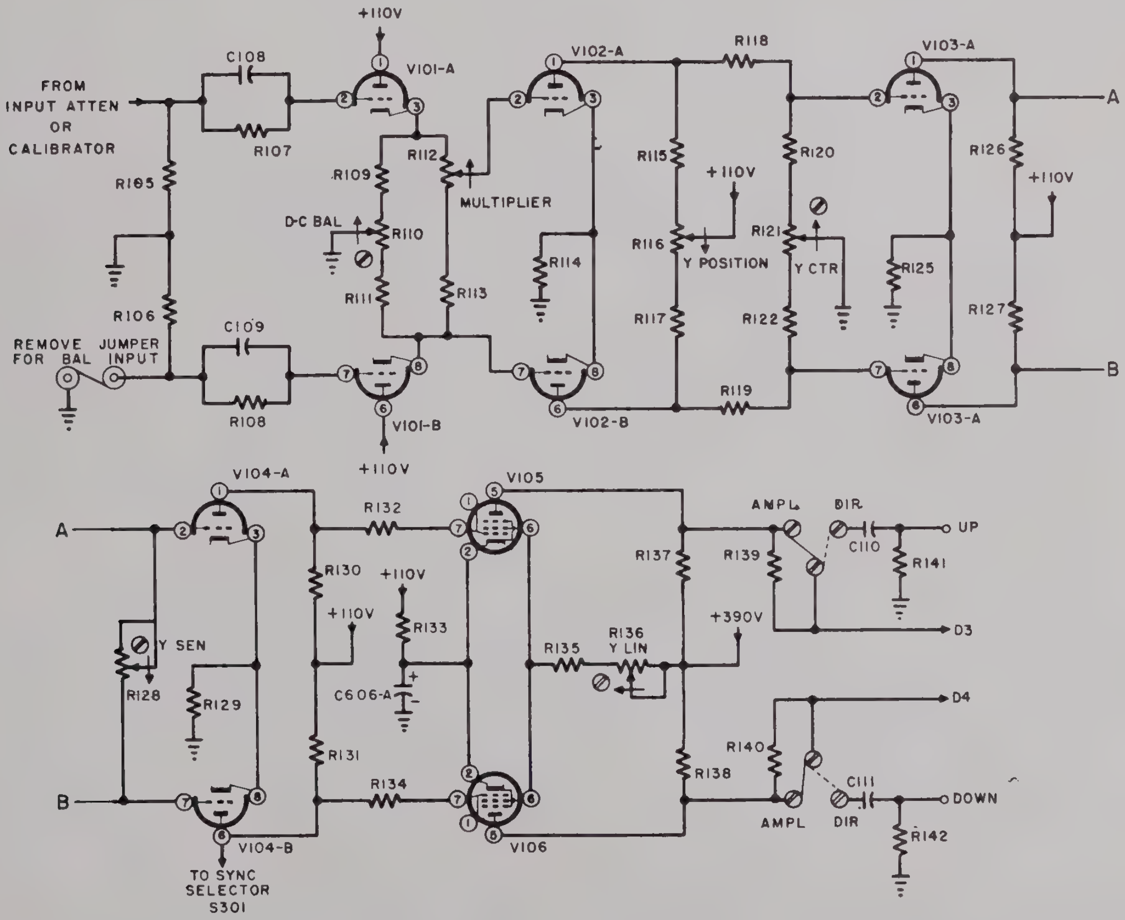


FIGURE 3-4. VERTICAL AMPLIFIER CIRCUIT (SIMPLIFIED SCHEMATIC)

(3) DIRECT INPUT

Provision is made for direct input to the vertical deflection plates at rear-panel terminals through series input capacitors C110 and C111. The coupling capacitors are required since the deflection plates are maintained at approximately +200 volts with respect to ground to prevent beam distortion.

4. SYNC AND SWEEP CIRCUITS

a. GENERAL

The sync and sweep circuits of both channels are similar. A simplified schematic of the sync and sweep circuits is shown in Figure 3-5. Provision is made for both driven and recurrent sweeps with expansion to six times full-screen diameter; the positioning range being sufficient to allow viewing on screen of any portion of the expanded sweep. The recurrent sweep may be synchronized or the driven sweep triggered by signals of either positive or negative polarity through the incorporation of a phase-splitting stage.

b. SYNCHRONIZATION

The SYNC SELECTOR switch (S301) provides for selection of the synchronizing signal; INTernal (signal obtained from the Y-axis amplifier); LINE-frequency; or EXTernal (signal obtained from an external source). V301-A functions as a sync phase splitter. The SYNC AMPLITUDE control (R308) enables the operator to select the desired amplitude and polarity of the sync voltage. The output from the first sync amplifier (V301-B is coupled to the grid of the sweep generator (V303) through C305 and R311. The plate of diode V302 is connected at the junction of R311 and R312; however, the cathode is connected to ground only when the X SELECTOR switch is set at RECURrent SWEEP. When thus connected in the circuit, this diode limits the sync voltage that can be applied to the sweep generator (V303) from charging to a positive potential at the higher sweep frequencies which would result in premature firing and erratic operation of V303. The useful sweep range is thus extended at the high-frequency end.

c. RECURRENT SWEEP

Gas triode V303 is employed to develop the sawtooth voltage necessary to obtain the linear sweep. The cathode of this gas triode is heated and emits electrons as in the ordinary heater-type triode, but the inert gas in the tube ionizes so that when the voltage between the cathode and the plate reaches a certain value, an arc occurs causing the tube to appear as a veritable short circuit. This "breakdown" or "firing" point depends upon the bias at the grid with respect to the cathode, the bias being determined by a voltage-divider network consisting of R313 and R314. With a specific negative bias applied to V302, it will "fire" at only one value of plate voltage. To facilitate circuit analysis, only one sweep capacitor is shown in Figure 3-5, connected between the plate and cathode of the gas triode. This capacitor is charged from the +360-volt supply through sweep-charging triode(V304-A, R316, R317 and the cathode bias resistance R314) until the plate voltage becomes high enough to "fire" the tube. At this time, the sweep capacitor is discharged until the plate-to-cathode voltage falls to the arc-extinction potential (about 20 volts). When this occurs, V303 no longer conducts and the charging cycle commences all over again. The SWEEP VERNIER control (R316) provides a fine adjustment of the sweep frequency by controlling the rate at which the sweep capacitor is charged.

The circuit of V304-A serves two functions; (1) to simulate the behavior of a constant current source for the linearization of the charging rate to the sweep capacitor and (2) to function as a sweep output cathode follower. The resultant sawtooth sweep appearing across the sweep output cathode follower load resistor (R320) is applied to a frequency-compensated voltage divider (R322, C313, and R323) which attenuates the sweep to approximately one fifth of the original value. The lower end of the voltage divider is connected to an adjustable negative bias at the arm of the SW DC LEVEL control (R403). When this back-of-panel adjustment is properly set, equal sweep-trace expansion from both sides of center screen will be obtained as the X AMPLITUDE control is advanced. The output from the voltage divider is coupled to the input of the X-axis amplifier when the X SELECTOR switch is set at the SWEEP position.

It is generally desirable to view only the forward portion of the sweep trace. This requires blanking of the return trace. To accomplish this, a negative pip is generated at the end of the forward trace by the differentiating circuit composed of R325 and C314. This negative pip is applied to the grid of the return-trace blanking amplifier (V305-A). The resulting positive pulse at the plate of V305-A is coupled to the cathode of the cathode-ray tube to "turn-off" the beam during the interval of the return trace.

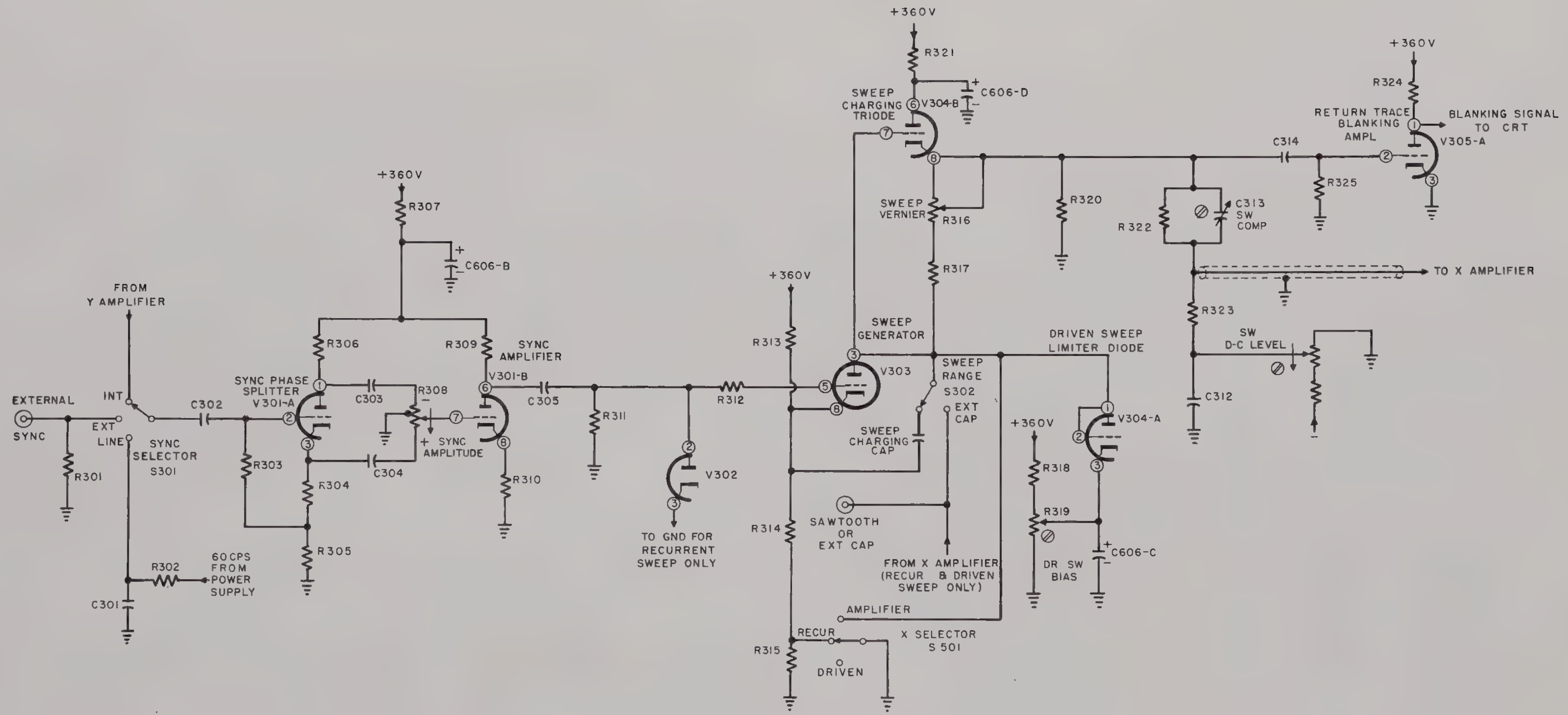


FIGURE 3-5 SYNC AND SWEEP CIRCUITS (SIMPLIFIED SCHEMATIC)

Certain applications may require sweep frequencies lower than two cycles per second. For such applications a very low-frequency time base may be obtained by connecting an external capacitor between the SAWTOOTH or EXT CAP front-panel terminal and ground when the SWEEP RANGE switch is set at EXT CAP. The larger the capacitor employed, the greater the R-C time constant and the lower the frequency.

d. DRIVEN SWEEP

For operation in the driven-sweep mode, the gas triode (V303) will not "fire" except when triggered by a positive pulse applied to its grid. Each positive pulse of sufficient amplitude initiates a single cycle of sawtooth voltage. When the X SELECTOR switch is at DRIVEN, the bias on the cathode of V303 is increased because of the addition of R315 in the voltage divider network. With this additional bias, a higher plate voltage must be applied to V303 before it "fires". The driven-sweep limiter diode (V304-A) prevents the plate of the gas triode from reaching the potential necessary for ionization under steady-state conditions. The functioning of this limiter is as follows: The limiter, (V304-A) will conduct when the forward portion of the sawtooth waveform reaches a certain amplitude as determined by the DRIVEN SW BIAS back-of-panel control adjustment (R319) in the cathode circuit. Upon conduction, the voltage across the sweep charging capacitor is arrested at this point; and when R319 is properly set, the voltage is of insufficient magnitude to fire that gas triode (V303).

The driven sweep is initiated by applying a positive pulse of sufficient magnitude to the grid of V303. This enables the tube to "fire" at a plate potential lower than that established by the fixed bias on the cathode. The sweep capacitor quickly discharges through the ionized conduction path of V303 to the extinction potential. At this point, conduction no longer occurs, and the sweep capacitor again charges. The driven sweep cycle is complete when the sweep capacitor again charges. The driven sweep cycle is complete when the sweep capacitor is again charged to the level established by the driven-sweep limiter diode (V304-A). The beam will sweep the screen again only upon application of another positive pulse to the grid of the gas triode.

5. HORIZONTAL DEFLECTION CIRCUIT (X AXIS)

a. GENERAL

A simplified schematic of the horizontal (X-axis) amplifier is shown in Figure 3-6. The horizontal amplifier, preceded by an input attenuator, consists of an input cathode follower, a paraphase amplifier stage and an output push-pull amplifier.

b. CIRCUIT THEORY

(1) X SELECTION

By means of the X SELECTOR switch (S501) provision is made for selection of internal or external signals for horizontal deflection. The internal signal is obtained from the linear sawtooth sweep circuit previously discussed. Either d-c or a-c external signals may be applied through the X attenuator, which provides attenuation ratios of 1 or 10. An OFF position is provided on this switch, which grounds the grid of the input cathode follower (V501-A).

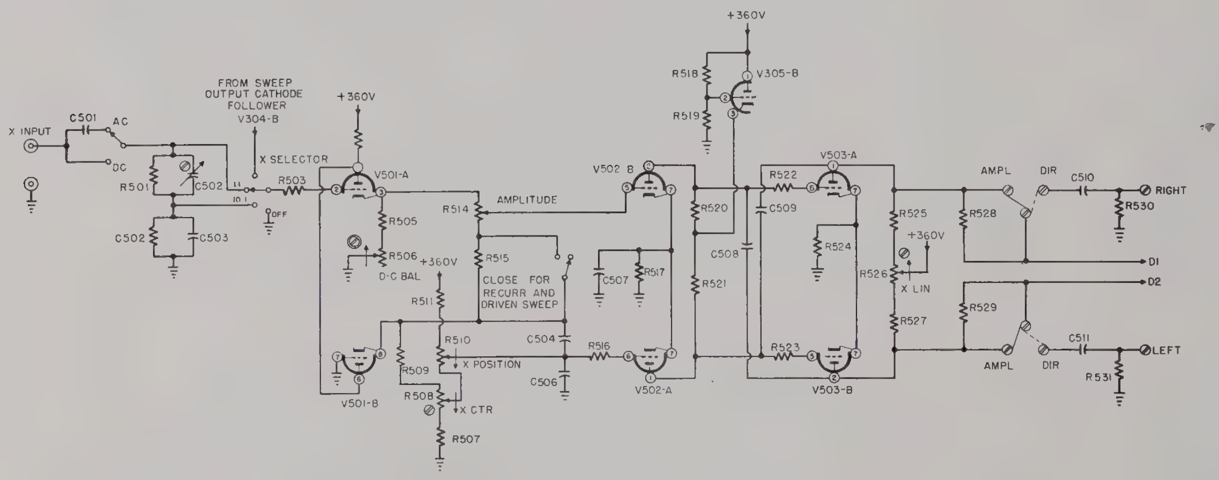


FIGURE 3-6. HORIZONTAL AMPLIFIER CIRCUIT (SIMPLIFIED SCHEMATIC)

(2) INPUT CATHODE FOLLOWER

V501-A and V501-B are connected in a cathode-follower circuit. V501-B has no signal applied to it; its function being solely to maintain the grid (pin 6) of the paraphase amplifier stage (V502) at signal ground potential while allowing d-c positioning voltage to be applied. The d-c balance adjustment (R506, X D-C BAL) is used to equalize the d-c voltage at the ends of the AMPLITUDE CONTROL. When this adjustment is properly set, there will be no shifting (left or right) of the trace when moving the AMPLITUDE control from minimum to maximum with no input to the amplifier.

The over-all gain of the X amplifier is varied by the AMPLITUDE control (R514). To prevent the operator from inadvertently overloading the input cathode follower with resultant signal distortion, R515 is connected in series with the AMPLITUDE control. The value chosen for R515 is such that with the AMPLITUDE control set for minimum gain, a signal large enough to overload the input cathode follower (V501) will cause the beam to be deflected off the screen of the cathode-ray tube and thus require additional attenuation to be employed. The range of the AMPLITUDE control is such that a signal, which causes 5 inches deflection of the electron beam on the screen at maximum AMPLITUDE control setting, will be cut down to between 0.1 and 0.5 inch at the minimum setting.

The input cathode follower is designed so as to maintain the cathode (pin 8) of V501-B at a constant signal potential of zero volts with respect to ground. This is important if V502 is to operate as a true paraphase amplifier with low distortion.

Assume that a positive-going signal is applied to the grid (pin 2) of V501-A. This tube will conduct more heavily, causing more current through the series cathode network consisting of R514, R515, R509, R508 and R507. The total current through the latter three resistances is not only determined by the cathode current just mentioned but also in part by the current flowing through V501-B. The increased plate current of V501-A produces a voltage drop across R504 in the plate circuit, which lowers the plate voltage on V501-B, resulting in less plate current rhrough this latter tube and the series network, R509, R508 and R507. This decrease in current through these resistances, when R504 is properly chosen, is just equal and opposite in phase to the current through the V501-A cathode network previously mentioned. Thus, the junction of R515 and R509 remains at the same (zero) potential. In practice, some small signal voltage may appear at this point; thus, C504 and C506 are provided as a capacitor voltage divider to provide high-frequency compensation.

(3) PARAPHASE AMPLIFIER

V502 is connected in a conventional paraphase amplifier circuit with plate voltage supplied through the series dropping stage (V305-B) from the +360-volt supply. V305-B, in addition to providing the proper voltage drop, serves as a low-impedance path to ground through the power supply.

(4) PUSH-PULL OUTPUT STAGE

The output of the paraphase amplifier is direct-coupled to a push-pull output amplifier (V503). Plate voltage for this stage is obtained from the +360-volt supply through a linearity control (R526, X LIN). This control is provided to compensate for any unbalance in the circuit caused by asymmetry of the two halves of the tube.

C508 and C509 provide sufficient feedback to cancel out the input capacitance of V502, resulting in improvement of the high-frequency response of the amplifier.

(5) BEAM POSITIONING

Beam positioning is accomplished by varying the bias voltage on V502-B with respect to that on V502-A through adjustment of the X POSITION control (R510). R508 (X CTR) is a back-of-panel adjustment in series with R510 for use in centering the beam on the screen with the X POSITION control set midway. This allows for equal positioning either side of center or may be adjusted for greater position in either direction from center, if desired.

(6) DIRECT INPUT

Connecting a signal direct to horizontal deflection plates is accomplished in the same manner as for vertical input discussed in paragraph 3d (3).

6. POWER SUPPLY

a. GENERAL

The circuit of the power supplies is shown on the over-all schematic at the back of the manual. As an aid in understanding the circuit, consider the power supply as consisting of three separate voltages: (1) low-voltage positive supply, (2) high-voltage positive and negative supply, and (3) heater supply.

b. FUNCTIONS

The low-voltage positive supply provides the necessary d-c potential for operation of the X and Y amplifiers, the sync and sweep circuits and, in addition, provides potential for the second anode of the cathode-ray tube. The high-voltage negative supply provides cathode, grid and first anode potentials for the cathode-ray tube. In addition, it furnishes the necessary bias for the SWeep DC LEVEL control. The high-voltage positive supply provides the necessary potential at the intensifier electrode of the cathode-ray tube. The heater supply furnishes the necessary low-voltage a-c potentials for proper operation of tube heaters.

c. LOW-VOLTAGE POWER SUPPLY

The low-voltage rectifiers (V605) is connected in a full-wave rectifier circuit. The rectifier output is filtered by a capacitor-input type filter (C602, L601, and C601). The full-voltage output from the filter (+360 volts) is regulated by V601 to provide +110 volts regulated. The unregulated +360-volt output supplies the Y amplifier output stages, sync sweep, and X amplifier. In addition, this supply furnishes voltage to the second anode and intensifier electrode of the cathode-ray tube.

d. HIGH-VOLTAGE POWER SUPPLY

The high-voltage power supply contains two rectifier circuits. These rectifiers provide the cathode-ray tube intensifier-anode potential as well as operating potentials for proper intensity and focusing of the cathode-ray tube beam. V604 is employed in a -1400 volt half-wave rectifier circuit from which the cathode, grid and first anode electrodes of the cathode-ray tube are supplied. The rectified output from this stage is filtered by a single pi section of an R-C type filter (C605, R606, and C604).

V603 is also connected in a half-wave rectifier circuit, the output from which is filtered by a single section R-C type filter. Potential at the output of this filter is approximately +1600 volts and supplies the necessary potential to the intensifier electrode of the cathode-ray tube.

e. REGULATED HEATER SUPPLY

A regulated heater supply on the first and second stages of the Y-axis amplifier provides good vertical stability. A series-connected thermal regulator (V606) controls the heater temperature to stabilize cathode emission over a ±10% range of variation in supply voltage.

SECTION IV

MAINTENANCE

WARNING!

This equipment employs high voltages that are dangerous and may be fatal if contacted by operating personnel. Extreme caution should be exercised when working on the equipment.

1. GENERAL SYSTEM TROUBLE SHOOTING

It is assumed that maintenance personnel are thoroughly familiar with the physical make-up of the equipment, the installation and operating procedures, and the detailed theory of operation given elsewhere in this handbook.

Maintenance personnel must be prepared to repair and adjust the equipment should it fail in operation. The trouble must be located; and after repairs have been made, the equipment must be tested and adjusted to conform to the original specifications. Maintenance personnel must endeavor to find the source of the trouble that causes each equipment failure, particularly when the trouble is a recurrent one. The recurrence of a fault usually indicates the effect, not the cause, has been remedied. No back-of-panel adjustment should be undertaken except where evidence points to trouble in the particular section of the instrument effected by the instrument.

2. THEORY OF LOCALIZATION

The first step in correcting any trouble or failure that may occur is to isolate the section of the circuit that is causing the trouble. Such isolation can be accomplished by considering the circuit as composed of the basic sections shown in the over-all block diagram, Figure 1-2. Trouble ordinarily occurs in only one section at a time; thus, it is usually necessary to correct only the one trouble. As an aid in servicing, Trouble Shooting Chart, Table 4-1 indicates causes of any remedies for certain specific troubles.

The next step after isolating the trouble to a particular section is to determine the tube circuit involved. A replacement tube should be tried before attempting any other tests. If trouble persists, voltage and resistance measurements should be made.

An over-all schematic of the circuit, together with a tube location diagram (Figure 4-5), will be found at the back of this section and should be consulted while trouble shooting. A list of component electrical parts, including descriptions, will be found on the reverse side of the schematic diagram.

TABLE 4 - 1.

TROUBLE SHOOTING CHART

POWER SUPPLY AND CRT CIRCUITS

Symptom	Probable Cause	Remedy
POWER indicator lamp fails to light.	POWER switch in OFF position.	Turn SCALE (POWER) switch on.
	No a-c line voltage .	Trace line failure.
	POWER indicator lamp open.	Replace 1405.
	Power cable defective.	Repair or replace cable.
	Filament transformer defective. (Check by measuring voltage across POWER indicator lamp. Terminals which should measure 6.3 volts a-c.	Replace T601.
	Fuse defective. (Make same check as in defective power cable.)	Replace F601
	115-230 Voltage Selector Switch (S601) defective	Make certain the 115/230 voltage selector switch is set at the proper voltage. Check continuity of switch with POWER at OFF. Replace switch if found defective. CAUTION: S601 must be wired in accordance with the overall schematic drawing to insure the proper phase relationship of primary transformer T601.
Line fuse blows instantly when POWER switch is turned "on".	Defective rectifier tube or filter capacitor.	Check filter capacitors C606-A C606-B, C606-C, C601 and C602 for low resistance or short. If found OK, replace rectifier tubes V15, V16 and V17. NOTE: If a filter capacitor is shorted, quite probably a rectifier tube may also be defective.
Some filaments fail to light.	Defective tube or tubes.	Replace burned out tubes.
	Broken lead from filament transformer. (Check filament voltage at tube socket and continuity to filament transformer T601.)	Repair
	Filament transformer, T601, defective. (Check filament voltage at each winding of T601.)	Replace.
Vertical displacement of trace with no input to Y amplifier.	No +110V regulated supply.	Replace Voltage Regulator V601.
Low beam intensity; increased deflection sensitivity of cathode-ray tube.	Positive high voltage rectifier defective.	Replace V603.
(No voltage on intensifier A3.)	R604 open circuited.	Replace.
	C603 or R605 shorted.	Replace.

TABLE 4-1
TROUBLE SHOOTING CHART
V~~OLTAGE AND RESISTANCE M~~EASUREMENTS (Continued)

Symptom	Probable Cause	Remedy
No spot on cathode-ray tube screen.	Defective negative high voltage rectifier V604. (Check voltage on cathode-ray tube--cathode (pin 2), grid (pin 3), first anode (pin 5). If voltage appears on any of these electrodes, as per Table 4-2, this is probably not the cause.)	Replace V604.
	C605 shorted.	Replace.
	R606 open-circuited.	Replace.
	C604 shorted.	Replace.
No spot on cathode-ray tube screen. (All CRT voltages normal.)	Defective cathode-ray tube (V401)	Replace V401.*
No sweep. Horizontal deflection circuit (X axis) checks OK.	X SELECTOR switch is not set at RECURrent SWEEP.	Rotate switch to RECURrent SWEEP.
	Inadequate amplitude of sync signal when X SELECTOR is set at DRIVEN.	Adjust SYNC AMPLITUDE control for the proper phase and amplitude of the synchronization signal.
	INTENSITY control set too low.	Increase INTENSITY.
	Sweep generator (V303) inoperative.	Check tube. * Check pin voltages and continuity to ground per Table 4-2.
	Sweep output cathode follower (V304-B) inoperative.	Check tube. * Check pin voltages and continuity to ground per Table 4-2.
	Sweep charging capacitors defective (C306, C307, C308, C310 and C311).	Replace defective capacitors.
No sweep. X SELECTOR switch set at RECURrent SWEEP.	DRiven SWeep BIAS out of adjustment (R319).	Readjust bias so that sweep starts operating. (Refer to the paragraph entitled, "Factory Adjustment for the Sweep Circuit" in this Section)
Sweep fails to expand equally in both directions as the AMPLITUDE control is advanced.	SWeep DC LEVEL control out of adjustment (R403).	Readjust R403.
Nonlinearity of sweep observed at a frequency of approximately 300 cycles per second.	Sweep-output attenuator trimmer requires adjustment (C313).	Refer to the paragraph entitled, "Factory Adjustment for the Sweep Circuit" in this Section.
No sweep available at SAWTOOTH when X SELECTOR switch is set at RECURrent SWEEP; sweep is present on cathode-ray tube screen.	Sweep coupling capacitor open (C505).	Replace.
	R512 open.	Replace.
	R513 shorted.	Replace. Check continuity of SWEEP RANGE switch (Section S3-C).
Horizontal trace present on cathode-ray tube screen when X SELECTOR switch is set at DRIVEN SWEEP. SYNC AMPLITUDE control is set at "0".	Driven sweep limiter diode (V304-A) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2. If V304-A checks OK, the DRiven SWeep BIAS is out of adjustment. Refer to the paragraph entitled, "Factory Adjustment for the Sweep Circuit" for the proper adjustment procedure.

TABLE 4-1
TROUBLE SHOOTING CHART
~~VOLTAGE AND RESISTANCE~~ MEASUREMENTS

Symptom	Probable Cause	Remedy
Loss of synchronization	Sync amplifier and phase splitter (V301) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2.
	SYNC SELECTOR switch is not in the proper position for the desired mode of operation.	Set SYNC SELECTOR switch at INTernal when X SELECTOR switch is set at either DRIVEN or RECURrent SWEEP. External sync signals may be employed if SYNC SELECTOR is set at EXTernal. If X SELECTOR is set at AMPLIFIER (AC or DC), SYNC SELECTOR must be set at EXTernal. If 60-cycle excitation is employed, SYNC SELECTOR should be set at LINE.
	SYNC AMPLITUDE control is not set to the proper polarity.	Change polarity.
	Defective coupling capacitors: C302, C303, C304 or C301	Replace defective capacitor.
Return trace is visible with normal INTENSITY control setting.	Differentiating network C314 and R325 defective.	Replace.
	Return trace blanking amplifier (V305-A) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2.
	Return trace blanking coupling capacitor open (C401).	Replace defective capacitor.
No sync of vertical deflection signals when SYNC SELECTOR switch is set at INTernal.	SYNC AMPLITUDE control defective (R308).	Replace.
	Sync coupling capacitor open (C302).	Replace.
	Sync amplifier and phase splitter (V7) inoperative.	Check tube. * Check pin voltages and continuity to ground per Table 4-2.
X SELECTOR switch is set at either DRIVEN or RECURrent SWEEP. Sweep is distorted at the maximum setting of the SYNC AMPLITUDE control.	Sync limiter diode (V302) inoperative.	Replace defective diode.
An appropriate negative signal applied to Z INPUT does not blank the trace.	Intensity modulation coupling capacitor open (C402).	An appropriate negative signal of approximately 15 volts peak is necessary to blank the trace If no result is experienced when this amplitude of signal is applied to Z Input, replace C402.
	R401 shorted.	Replace.

TABLE 4-1

TROUBLE SHOOTING CHART

~~VOLTAGE AND RESISTANCE~~ MEASUREMENTS (Continued)

Sympton	Probable Cause	Remedy
VERTICAL DEFLECTION CIRCUIT (Y AXIS)		
An appropriate signal is applied to Y INPUT. No vertical displacement of the trace results.	VOLTS FULL SCALE (attenuator) switch is set at OFF.	Set VOLTS FULL SCALE (attenuator) to either A-C or D-C AMPLIFIER.
	One or more of the vertical deflection circuit tubes are inoperative (VI through V6 inclusive).	Check tubes.* Check pin voltages and continuity to ground per. Table 4-2.
No vertical signal when VOLTS FULL SCALE is set at A-C AMPLIFIER; signal is present when VOLTS FULL SCALE is switched to D-C AMPLIFIER	Input coupling capacitor open (C101).	Replace.
A 5-kc square wave, applied to Y INPUT, is distorted at all AMPLIFIER positions of the VOLTS FULL SCALE.	Y attenuator compensation capacitors out of adjustment (C102, C104 and C106).	Refer to the paragraph entitled, "Factory Adjustments for the Y Amplifier" for the proper adjustment procedure.
Y POSITION control is set at center of its range; trace is not centered vertically on cathode-ray tube screen.	Position centering adjustment (Y CTR) out of adjustment (R121).	Set VOLTS FULL SCALE at OFF and Y POSITION control at the mechanical center of its range; adjust R121 to bring the trace on the cathode-ray tube to the vertical center of the screen.
VOLTS FULL SCALE is set at OFF; CRT trace shifts (up and down) with changes in the setting of the MULTIPLIER (amplitude) control.	D-C BALance control out of adjustment (R110)	Refer to the paragraph entitled, "Factory Adjustments for the Y Amplifier" in this Section for the proper adjustment procedure.
Size of pattern changes as it is positioned vertically on CRT screen.	Y LINearity out of adjustment (R136) .	Refer to the paragraph entitled, "Factory Adjustment for the Y Amplifier" in the Section for the proper adjustment procedure.
No vertical displacement of CRT trace when a signal is applied to the appropriate vertical deflection-plate input terminals. (Jumpers are connected for direct input).	Direct input coupling capacitor(s) open (C110 and/or C111).	Replace
HORIZONTAL DEFLECTION CIRCUIT (X AXIS)		
No sweep. Sweep circuit checks OK; X SELECTOR is set at RECURrent SWEEP.	Check continuity of X SELECTOR SWitch (Section S501-2R).	Repair or replace if found defective.
	Horizontal deflection circuit (X axis) inoperative.	Check horizontal deflection circuit (X axis) as outlined in this chart below.
An appropriate signal is applied to X INPUT. No horizontal displacement of the trace results. (X SELECTOR is set at either A-C or D-C AMPLIFIER)	One or more of the horizontal deflection circuit tubes are inoperative (V305-B and V501 through V503).	Check Tubes.*

TABLE 4-1
TROUBLE SHOOTING CHART
~~VOLTAGE AND RESISTANCE~~ MEASUREMENTS (Continued)

Symptom	Probable Cause	Remedy
No horizontal signal when X SELECTOR is set at A-C AMPLIFIER; signal is present when X SELECTOR is switched to D-C AMPLIFIER.	Input coupling capacitor open (C501).	Replace.
X POSITION control is set at center of its range; trace is not centered horizontally on the cathode-ray tube screen.	Position centering adjustment (X CTR) out of adjustment (R508).	Set X SELECTOR at OFF and X POSITION control at the mechanical center of its range; adjust R508 to bring the trace on the cathode-ray tube to the horizontal center of the screen.
X SELECTOR is set at OFF; CRT trace shifts (left and right) with changes in the setting of the AMPLITUDE control.	D-C BALance control out of adjustment (R506).	Refer to the paragraph entitled "Factory Adjustments for the X Amplifier" on this Section for the proper adjustment procedure.
Size of pattern changes as it is positioned horizontally on CRT screen.	X LINearity out of adjustment (R526).	Refer to the paragraph entitled "Factory Adjustments for the X Amplifier" in this Section for the proper adjustment procedure.
No horizontal displacement of CRT trace when a signal is applied to the appropriate horizontal deflection-plate input terminals. (Jumpers are connected for direct input).	Direct input coupling capacitor(s) open (C510 and/or C511).	Replace.

*If tube replacement is necessary, refer to "Adjustments to be Made When Replacing Tubes, "Table 4-3.

3. CIRCUIT VOLTAGES AND RESISTANCES

Table 4-2 lists voltages and resistances from tube pins to ground. Unless otherwise specified, voltage measurements are made with a meter having an internal resistance of 20,000 ohms per volt. Voltages measured with a meter having a lower internal resistance may in some cases be lower than the values shown in the table.

It should be remembered that all values are nominal, and considerable variation may be experienced due to various line-voltage conditions and component tolerance. Generally, a variation of ±10% is to be expected and ±20% may not be uncommon. Good judgment is often required to determine if a particular deviation is indicative of trouble.

TABLE 4-2

VOLTAGE AND RESISTANCE MEASUREMENTS*

Present front-panel controls according to the following chart:

CONTROL	POSITION	CONTROL	POSITION
Y POSITION	CENTER	VOLTS FULL SCALE	Off
X POSITION	CENTER	X SELECTOR	Recur
INTENSITY	MAX CCW	SWEEP RANGE	50-250
FOCUS	MAX CW	MULTIPLIER	4
SYNC SELECTOR	LINE	(X) AMPLITUDE	Max CCW
SWEEP VERNIER	CENTER	CALIBRATOR	Off
SYNC AMPLITUDE	MAX CCW		

*Obtained when using a 20,000 ohms-volt test meter. Readings are typical and nominal and may vary by as much as 20% or more in some cases. All voltages are d-c unless otherwise indicated.

TABLE 4-2 (CONTINUED)

TUBE			PIN NUMBERS									
SYMBOL	TYPE	FUNCTION	1	2	3	4	5	6	7	8	9	
V101	5963	Input Cathode Follower	20K	220K	4.4K	4	4	20K	220K	4.4K	0	
			110V	0V	5V	5.8V AC	5.8V AC	110V	0V	5V	0V	
V102	5963	Paraphase Amplifier	20K	5K	1.5K	4	4	20K	4.4K	1.5K	1	
			62V	5.5V	7V	5.8V AC	5.8V AC	62V	5.5V	7V		
V103	12AU7	1st Push-Pull Amplifier	30K	17.5K	8.2K	0	0	30K	17.5K	8.2K	0	
			65V	32V	33V	3.2V AC	3.2V AC	65V	32V	33V	3.2V AC	
V104	12AU7	2nd Push-Pull Amplifier	20K	30K	28K	0	0	22K	30K	28K	0	
			100V	65V	65V	3VAC	3VAC	100V	65V	65V	3VAC	
V105	6AQ5	3rd Push-Pull Amplifier		18K	0	0	44K	140K	24K			
				107V	3VAC	3VAC	180V	218V	100V			
V106	6AQ5	3rd Push-Pull Amplifier		18K	0	0	44K	140K	24K			
				107V	3VAC	3VAC	180V	218V	100V			
V301	12AU7	(a) Sync Amplifier (b) Sync Phase Splitter	90K	2.2K Meg.	10K	0	0	280K	100K	1.8K	0	
			100V	**10V	19V	3VAC	3VAC	20V	0V	0.8V	3VAC	
V302	6AL5	Sync Limiter Diode		100K	0	0	0					
				-0.5V	3VAC	3VAC	0V					
V303	6Q5G	Sweep Generator		0	330K	1K	120K		0	2K		
				3VAC	30V	4.2V	-0.4 V		3VAC	3.6V		
V304	12AU7	(a) Driven Sweep Limiter (b) Sweep Output Cathode Follower	350K	350K	20K	0	0	35K	350K	175K		
			30V	30V	55V	3VAC	3VAC	340V	30V	60V	3VAC	
V305	12AU7	(a) Return Trace Blanking Amplifier (b) Series Dropping Triode	125K	15K	0	0	0	20K	125K	18K	0	
			35V	-0.3V	0V	3VAC	3VAC	340V	65V	75V	3VAC	

** *Obtained when using a vacuum-tube voltmeter*

TABLE 4-2 (CONTINUED)

V501	12AU7	Input Cathode Follower	30K	200K	8K	0	0	30K	0	6K	0	
			310V	0V	18V	3.1V AC	3.1V AC	310V	0V	18V	3.1V AC	
V502	6J6	Paraphase Amplifier	28K	28K	0	0	7K	10K	5.6K			
			58V	58V	3VAC	3VAC	18V	18V	19V			
V503	6J6	Push-Pull Amplifier	83K	83K	0	0	28K	28K	12K			
			200V	200V	3VAC	3VAC	58V	58V	75V			
V601	OB2	+110V Voltage Regulator					20K		0			
							110V		0V			
V602	6AL5	Voltage Calibrator	65K	0	0	0	200K		200K			
			128V	0V	3VAC	3VAC	65V		65V			
V603	1X2A	+1600 V Rectifier	2K	2K								CAP
			1600V DC	1600V DC								1380VAC
V604	1X2A	-1400 V Rectifier	10 Meg	10 Meg								CAP
			1380V AC	1380V AC								-1400 VDC
V605	5Y3GT	+340 V Rectifier		20K		175		175		20K		
				370V		400V AC		400V AC		370V		
V606	3-14	Amperite Regulator		5.5					6.5	5.5		
				5.6V AC					24.5V AC	5.8V AC		
V401	5ADP-	Cathode-ray Tube	1	2	3	5	7	8	9	10	11	14 A3
			1 Meg	1 Meg	1.2 Meg	700K	45K	45K	44K	100K	70K	1 Meg 0
			-1400 V	-1400 V	-1400 V	-900 V	+180 V	+180 V	190V	200V	200V	-1400 V +1600 V

4. SELECTING 115- OR 230- VOLT LINE

Provision is made in the Types 304-A and 304-AR for changing from 115 to 230-volt line operation or vice versa. To accomplish this, remove the chassis or dust cover and set the 115/230-volt selector switch (S601), located at the rear of the chassis, at the desired voltage. Replace fuses in accordance with the appropriate note on the over-all schematic at the back of this section.

5. FACTORY ADJUSTMENTS

a. GENERAL

> - WARNING -
>
> POTENTIALS AS HIGH AS 3200 VOLTS ARE EMPLOYED IN THIS EQUIPMENT. OBSERVE THE FOLLOWING PRECAUTIONS WHEN NECESSARY TO ENERGIZE THE EQUIPMENT WITH THE CABINET REMOVED.
>
> (1) Never work alone.
> (2) Make sure the chassis is properly grounded. (Do not depend upon a ground connection made by touching the chassis. Make ground connections directly to one of the ground binding posts.)
> (3) Remove power before changing any tube or attaching any test leads. Remove power cord from the line outlet.
> (4) Before touching any component, short the terminals to remove any possible charge that may remain after turning off the power
> (5) Work with one hand in your pocket.

In order to avoid component pre-selection, a number of factory adjustments have been included in this instrument. Only two such adjustments are necessary if the instrument is operating normally. These are the D-C BALance adjustments for the X and Y amplifiers, located on the front panel of the instrument. Certain factory adjustments may need to be reset when replacing tubes; Table 4-3 lists these adjustments. Before making any adjustments, a 10-minute warm-up period should be allowed. For identification and location of the back-of-panel controls, see Figures 4-1 through 4-3. Although these are photos of the Type 304-A chassis, relative location of controls on the Type 304-AR is the same; and no difficulty should be experienced in identifying them on the Type 304-AR chassis.

b. TEST EQUIPMENT REQUIRED

Description	Range of Characteristics
Volt-ohmmeter	20,000 ohms/volt test meter or VTVM
Voltage Calibrator	Du Mont Type 264-B or equivalent
Square-wave Generator	60 cycles to 10 kc

TABLE 4-3.

ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

Tube Reference Symbol	Type	1 st Readjustment	2 nd Readjustment	3 rd Readjustment
V101**	5963	(Y)D-C BAL (R110)		
V102**	5963	Y CTR (R121)	Y SEN (R128)	*Y CTR (R121)
V103	12AU7[+]	Y SEN (R128)	Y CTR (R121)	
V104	12AU7[+]	Y LIN (R136)	Y SEN (R128)	Y CTR (R121)
V105	6AQ5	Y LIN (R136)	Y SEN (R128)	Y CTR (R121)
V106	6AQ5	Y LIN (R136)	Y SEN (R128)	Y CTR (R121)
V301	12AU7[+]			
V302	6Q5G	DR SW BIAS (R319)	SW D-C LEVEL (R403)	LF ADJ (R315)
V303	12AU7[+]			
V304	12AU7[+]			
V401	B1033	Y SEN (R128)	Y CTR (R121)	
V501**	12AU7[+]	(X)D-C BAL (R506)	X CTR (R508)	
V502	6J6	X CTR (R508)		
V503	6J6	X LIN (R526)		
V601	OB2			
V602	6AL5	CAL ADJ (R602)	Y SEN (R128)	Y CTR (R121)
V603	1X2A			
V604	1X2A			
V605	5Y3GT			
V606	3-14			

*The Y CTR control needs readjustment at this point because the Y POSITION control is dependent on Y SEN. The latter control cannot be listed as the second readjustment when replacing V102 because in doing so may result in displacing the pattern so far off the screen that the Y POSITION control has no effect on the pattern.

**V101, V102, and V501 are preselected tubes and may prove critical in replacement. The Du Mont Instrument Service Department can supply tubes specifically selected for these positions.

[+] Type 5963 tubes may be substituted for Type 12AU7 with no loss in performance, provided balanced tubes are selected where necessary.

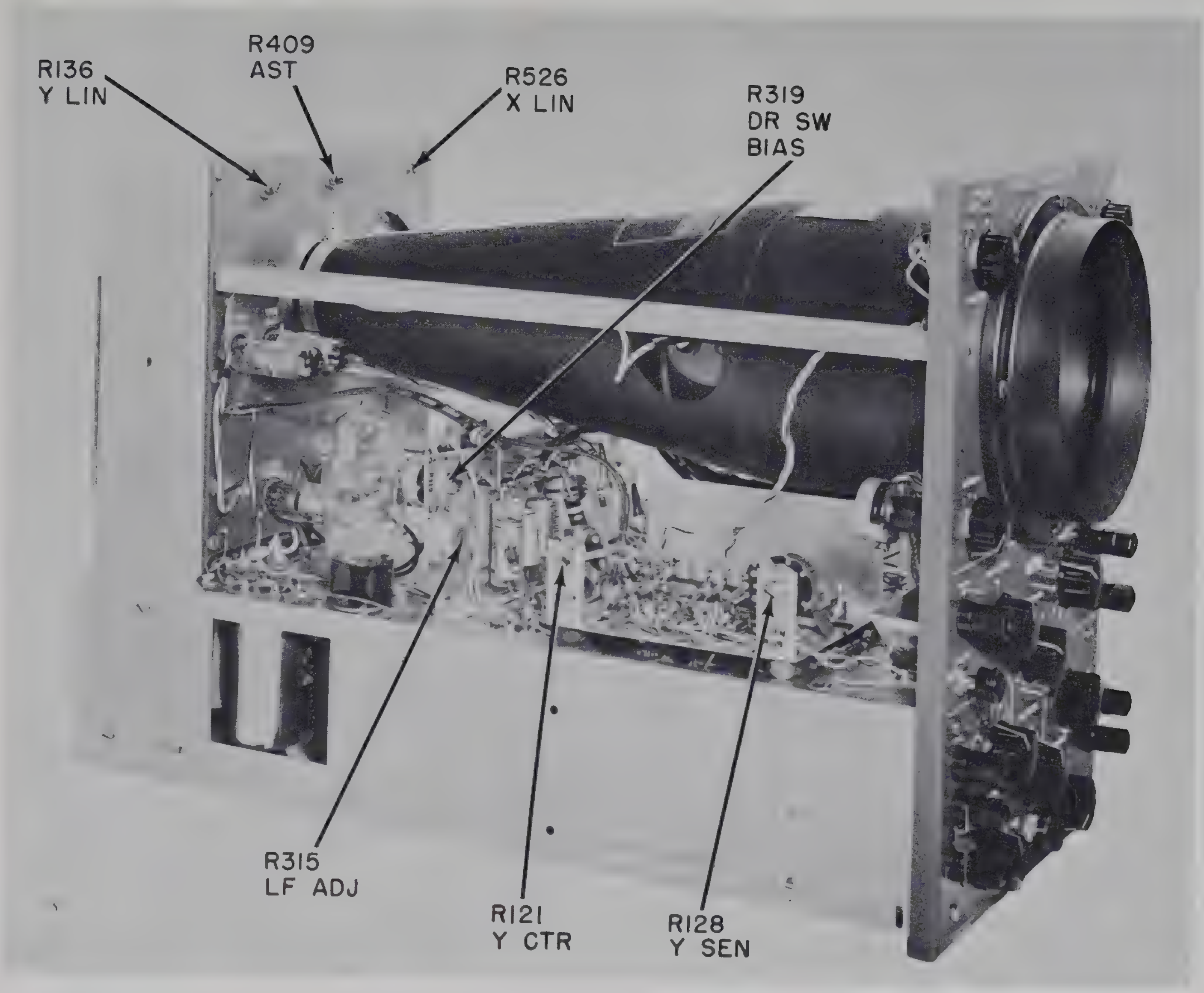


FIGURE 4-1. IDENTIFICATION OF BACK OF PANEL CONTROLS, LEFT SIDE

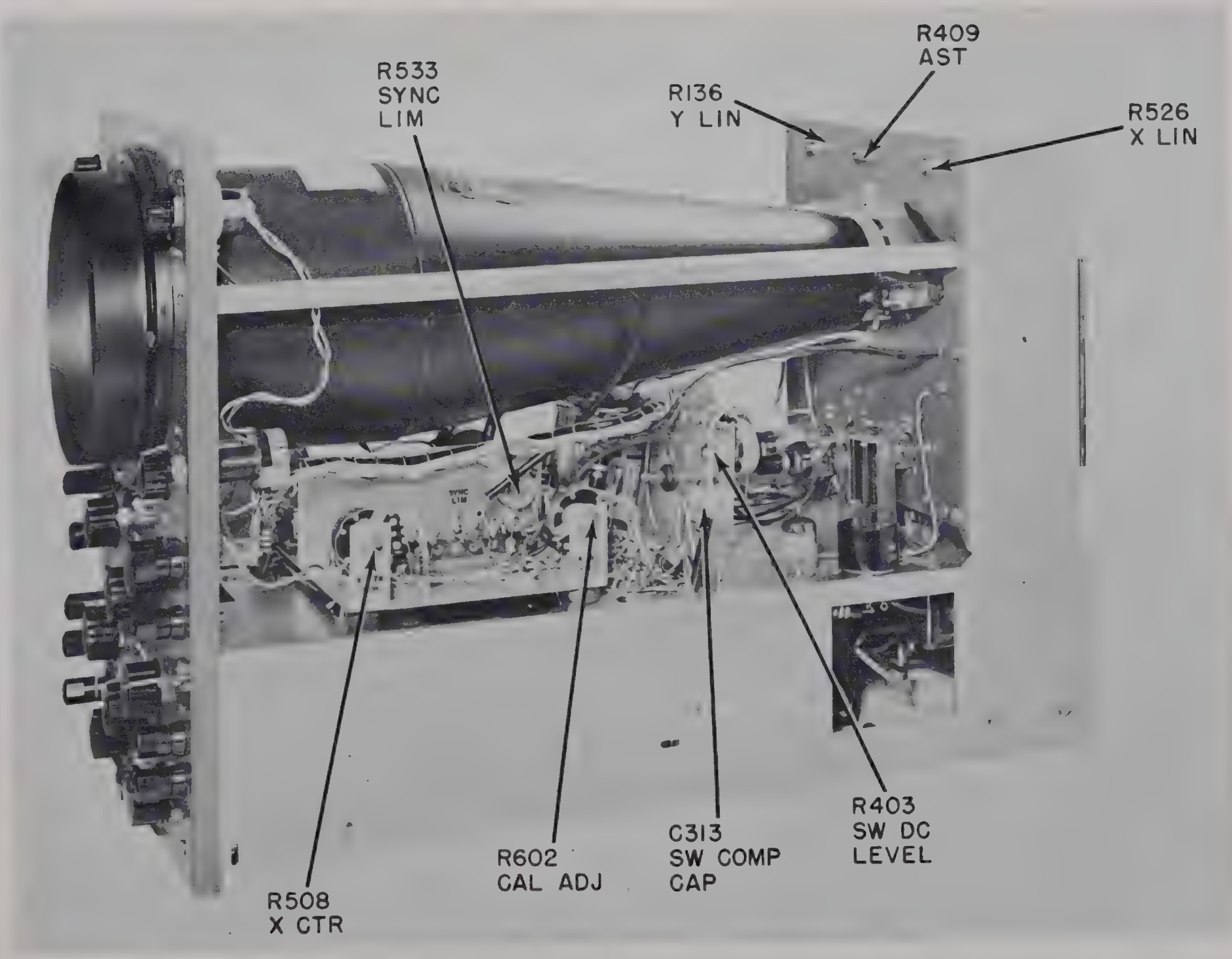


FIGURE 4-2. IDENTIFICATION OF BACK OF PANEL CONTROLS, RIGHT SIDE

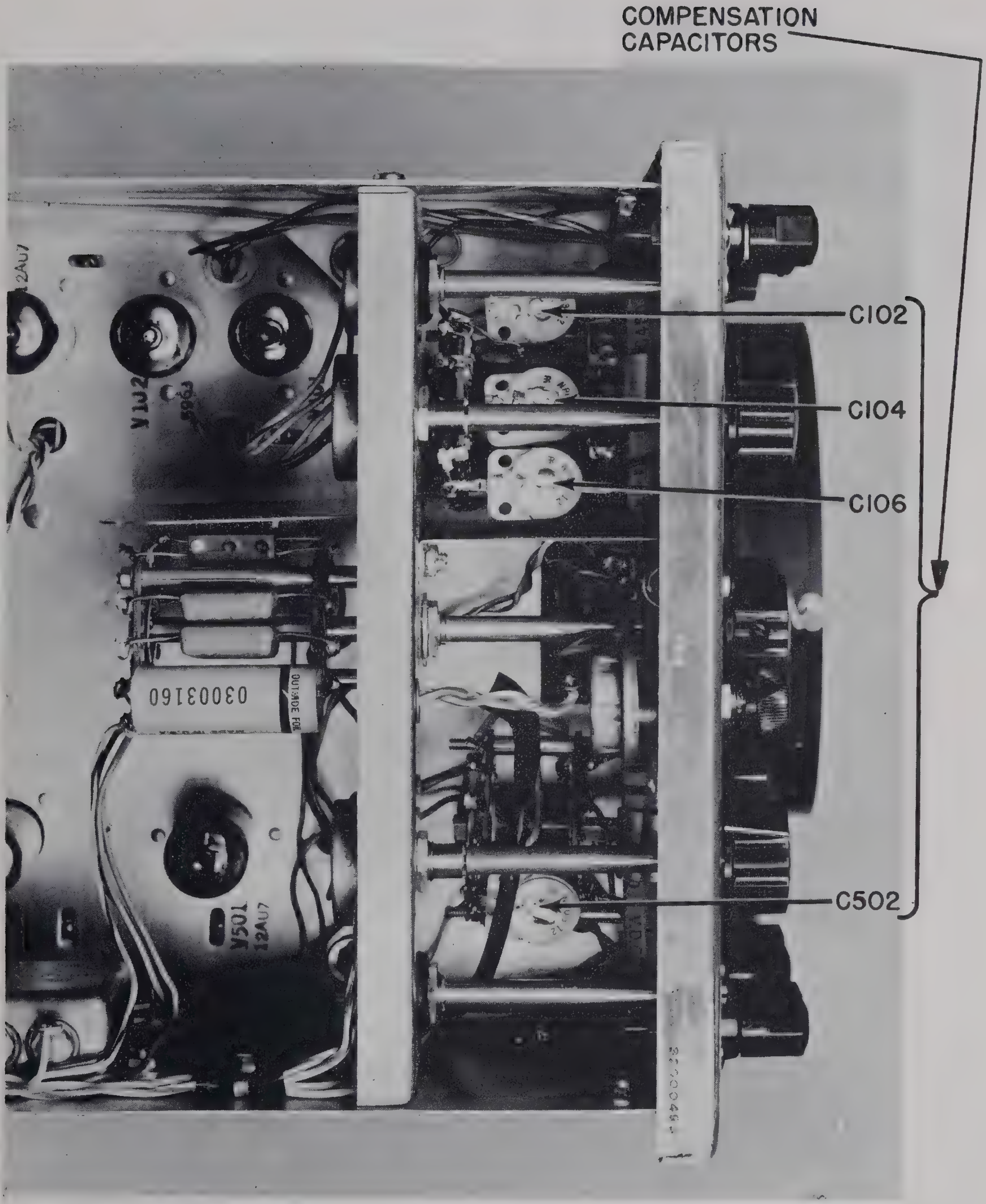


FIGURE 4-3. IDENTIFICATION OF BACK OF PANEL CONTROLS, BOTTOM FRONT

c. FACTORY ADJUSTMENTS FOR Y AMPLIFIER

(1) Position Centering Adjustment (Y CTR) - R121 - This adjustment is set to bring the trace on the cathode-ray tube to the center of the screen vertically with no signal input (VOLTS FULL SCALE) at OFF and Y POSITION control at the mechanical center of its range (pointing up).

(2) Sensitivity Adjustment (Y SEN) - R128 - This control should be set to give the amplifier a sensitivity of 9 millivolts per inch rms or 25 millivolts per inch dc at full gain. To make this adjustment, refer to the paragraph entitled "Factory Adjustments for the Voltage Calibrator" in this section.

(3) Linearity Adjustment (Y LIN) - R136 - To make this adjustment,apply a square-wave signal to the Y INPUT and adjust for 1 inch vertical deflection at the center of the screen. Position pattern 1-1/2 inches up and 1-1/2 inches down and observe whether vertical size of pattern becomes greater, or smaller, away from the center of the screen. If the size changes, adjust the Y LIN control until a minimum change in size with positioning occurs. When this adjustment is made, reset the Y CTR adjustment (R121). It may also be necessary to recheck the Y SEN adjustment (R128).

(4) D-C Balance Adjustment (D-C BAL)-R110 - In addition to the back-of-panel factory adjustments, the amplifier is supplied with a D-C Balance control, which may be adjusted by means of a screwdriver at the front panel. See Figure 2-1 for location. When this adjustment is properly set, there will be no shifting in the zero position (up and down) with changes in the setting of the MULTIPLIER control. Since this adjustment requires occasional resetting, owing to aging of components, it is made readily accessible to the operator. To set the D-C Balance adjustment, set the VOLTS FULL SCALE switch to the OFF position and the MULTIPLIER control at the extreme left. Position the trace to the vertical center of the cathode-ray tube. Set the MULTIPLIER control to 1, and adjust D-C Balance to return the trace to its previous position. It should now be possible to move the MULTIPLIER control from 10 to 1 without any vertical displacement resulting. Repeat the adjustment procedure if any vertical displacement is observed.

(5) Input Attenuator Compensation Capacitors - The trimmer capacitors C102, C104 and C106 are used for compensating the input attenuator (VOLTS FULL SCALE) in the 1V, 10V, and 100V positions

respectively. Compensation should be adjusted by applying a 10-kc square wave to the Y INPUT terminals and adjusting the appropriate trimmer to pass the square wave to the Y INPUT terminals and adjusting the appropriate trimmer to pass the square wave with minimum of distortion. In Figure 4-4 "A" represents proper adjustments, while "B" and "C" represent conditions of over-compensation and undercompensation, respectively.

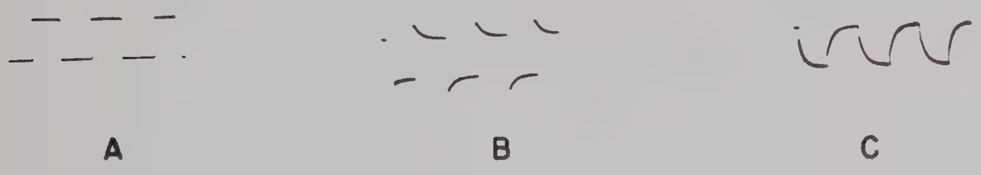


FIGURE 4-4. WAVEFORMS ENCOUNTERED IN ADJUSTING THE Y ATTENUATOR

d. FACTORY ADJUSTMENTS FOR X AMPLIFIER

(1) Linearity Adjustment (X LIN) - R526 - To set this adjustment, obtain a one-inch sweep in the horizontal center of the screen Position the pattern 1-1/2 inches to the left and 1-1/2 inches to the right of center; observe whether the horizontal amplitude of the pattern is greater at the left side or the right side of center. Then adjust R526 until the pattern has the same amplitude on both sides of center.

(2) D-C Balance Adjustment (D-C BAL) - R506 - When this control is properly adjusted, there will be no shifting in the zero position (left and right) with changes in the setting of the (X) AMPLITUDE control. Position the trace in the horizontal center of the cathode-ray tube screen. Increase the AMPLITUDE control to 100 (fully clockwise) and adjust the D-C Balance to return the trace in the horizontal center of the cathode-ray tube screen. Increase the AMPLITUDE control to 100 (fully clockwise) and adjust the D-C Balance to return the trace to its previous position. It should now be possible to move the AMPLITUDE control over its full range without any horizontal displacement taking place. Repeat the adjustment procedure if any horizontal displacement is observed.

(3) Position Centering Adjustment (X CTR) - R508 - With no signal input (X SELECTOR at OFF) and the X POSITION con-

trol at the mechanical center of its range (pointing up), adjust R508 to bring the trace on the cathode-ray tube to the center of the screen horizontally.

(4) X Attenuator Compensation Capacitor - C502 - This adjustment is made by applying the 10-kc square-wave signal to the X INPUT terminals and setting the X SELECTOR switch at 10. It is not necessary to apply a signal to the Y INPUT. Proper adjustment of the X attenuator is obtained when the dots at each end of the horizontal trace are of maximum relative intensity and in sharpest focus.

e. FACTORY ADJUSTMENTS FOR THE SWEEPS

(1) Driven Sweep Bias (DR SW BIAS) - R319 - To properly adjust for normal operation of the driven sweep, set the SWEEP RANGE switch at the 2-10 cps position; set the SYNC AMPLITUDE control at zero, the SWEEP VERNIER fully clockwise and the SYNC LIMITING (screwdriver) adjustment fully counter-clockwise. Push in the CALIBRATOR button, and adjust the MULTIPLIER control for about 0.4 inch vertical deflection. Set the X SELECTOR switch to DRIVEN SWEEP and adjust the driven sweep bias potentiometer until the sweep just stops and a vertical bar appears. Check this setting with the SWEEP VERNIER turned completely counter-clockwise also making certain that this adjustment in no way affects normal operation of the sweep on RECUR rent. Set the SYNC SELECTOR switch at INT. It should now be possible to trigger the "driven sweep" by rotating the SYNC AMPLITUDE control either way from "0". Check for proper triggering of the "driven sweep" with the SWEEP VERNIER control turned completely counterclockwise. If the sweep fails to trigger in this case, increase the vertical amplitude of the signal to a maximum of 0.75 inches. If the SYNC AMPLITUDE control, when fully advanced, still does not trigger the "driven sweep", the sweep thyratron (V303) may be defective.

(2) SYNC LIMITER (SYNC LIM) - R533 - Adjust the DRiven SWeep BIAS control as outlined in paragraph e (1) above. Adjust pattern for 0.4 inch vertical deflection and advance the SYNC AMPLITUDE control just enough to trigger the sweep. Proper adjustment of the SYNC LIMiter control is obtained by advancing it from its extremely counterclockwise position to a point where the sweep stops and then "backing it off" to a point where the sweep just starts again and is stable.

(3) Sweep DC Level Adjustment (SW DC LEVEL) - R403 - This adjustment should be made so as to allow the sweep to expand equally in both directions as the (X) AMPLITUDE control is advanced.

(4) Sweep-output Attenuator Trimmer - C313 - The sweep-output attenuator is adjusted for optimum linearity and minimum "tail" of the sawtooth waveform, using a frequency of approximately 300 cps. To adjust, set the X SELECTOR at RECURrent SWEEP, SWEEP RANGE switch at 250-1240; connect a test lead from the SAWTOOTH TEST SIGNAL terminal to the Y INPUT terminal and adjust to two-inch vertical deflection. Observe the waveform on the cathode-ray tube screen of the Type 304-A while adjusting the trimmer for minimum "tail" on the sawtooth wave.

(5) Sweep Low-frequency Adjustment (LF ADJ) - R315 - Feed a four-cycle sine-wave signal to the Y INPUT terminal. With SWEEP RANGE set at 2 and SWEEP VERNIER set at 10, adjust R315 for a two-cycle pattern on the screen.

f. FACTORY ADJUSTMENTS FOR THE VOLTAGE CALIBRATOR

(1) Voltage Calibrator Adjustment (CAL ADJ) - R602 - The voltage calibrator adjustment is set by comparison with a Du Mont Type 264-B Voltage Calibrator or equivalent, connected to the Y INPUT terminals. Set front-panel controls as follows:

CONTROL	POSITION
VOLTS FULL SCALE	0.1
MULTIPLIER	1
X SELECTOR	RECURrent SWEEP
SWEEP RANGE	50-250
SYNC SELECTOR	LINE

Push the CALIBRATOR switch and adjust the SYNC AMPLITUDE and SWEEP VERNIER controls for several cycles display on the cathode-ray tube screen. The proper adjustment is obtained when CAL ADJ (R602) is adjusted to produce the same vertical displacement of the beam (CALIBRATOR switch pushed in) as an 0.1 volt signal from the standard voltage calibrator produces (CALIBRATOR switch released .... e.g. out).

(2) Amplitude Calibration of Y Amplifier

Adjust the front-panel controls as indicated in the preceding paragraph to obtain several cycles display on the screen. Adjust

R128 (Y SENsitivity adjustment) for a vertical deflection of four inches. The Y amplifier is now adjusted for a sensitivity of 25 millivolts peak-to-peak per inch at full gain. To release the CALIBRATOR switch, push in.

g. OTHER FACTORY ADJUSTMENTS

(1) Astigmatism Control (AST) - R409 -- Apply a 60-cycle sine-wave test signal to the Y INPUT terminal. Synchronize one or two cycles of this signal on the screen, and expand the trace to full-screen diameter. Adjust the FOCUS control for sharpest trace. Then adjust the ASTigmatism control (by means of a screw-driver inserted through the hole provided in the rear of the cabinet) for uniform width of trace from start to finish. It will probably be necessary to readjust the FOCUS control simultaneously with the ASTigmatism potentiometer to maintain best focus. Once properly adjusted, the ASTigmatism control should require no further attention under normal conditions.

6. REPLACEMENT OF CATHODE-RAY TUBE

a. TYPE 304-A

To replace the Type 5ADP - Cathode-ray Tube in the Type 304-A, removal of the old tube may be accomplished as follows: Disconnect the power cord from the line; remove the two screws holding the rear of the cabinet; and carefully slide the instrument forward until it is clear of the cabinet. Detach the circular ring (bezel) and calibrated scale from the front panel by removing the four screws which hold them in place. Next, loosen the screw holding the tube-base clamp. Remove the cathode-ray tube socket, and the intensifier button. The tube may now be removed through the front-panel opening.

Insert the new cathode-ray tube through the front-panel opening and the tube shield. When inserting the tube, the intensifier pin should be on the left side of the tube as viewed from the front of the instrument. Push the tube in far enough so that the base goes into the base clamp provided. Connect the base socket to the tube.

CAUTION

The cathode-ray tube should be inserted with great care to prevent damage which might result in personal injury. Do not employ force at any time As an added precaution, wear safety goggles and gloves.

Connect the intensifier button to the intensifier pin. Replace the calibrated scale and the bezel; move the tube forward so that it just touches the scale. Connect the power cord to the line; turn on the instrument and set X SELECTOR to RECUR-rent SWEEP. If the resulting trace is not horizontal, rotate the tube slithly until it is. Disconnect the power cord from the line and tighten the tube-base clamp.

Slide the instrument back into its cabinet and replace the two screws at the rear which hold the chassis in place.

b. TYPE 304-AR

To replace the Type 5 ADP- Cathode-ray Tube in the Type 304-AR, first remove the dust cover by loosening the screws on either side and rear that hold the dust cover to the chassis. In all other respects, removal and replacement of the cathode-ray tube is accomplished in the manner described for the Type 304-A.

7. ILLUMINATED CALIBRATED SCALE

As an aid in amplitude and time calibration, both for visual measurements and for permanent records by photographic recording, an illuminated scale over the face of the cathode-ray tube, provided with a dimmer control, is a part of the Type 304-A. The illumination lamps are located behind the front panel. To replace a defective lamp, remove the cabinet as indicated in paragraph 5 above. Slide the lamp assembly from the tongue support and replace the defective bulb. To insure proper illumination, when replacing the lamp assembly, make certain that the bulb enters the front-panel aperture provided for it as far as it will go.

8. DU MONT "OSCILLOGRAPHER"

The Du Mont "Oscillographer", a quarterly publication, is published regularly by the Allen B. Du Mont Laboratories, Inc. It is sent free of charge to engineers, research workers, and those engaged in the use and application of cathode-ray equipment. When requesting this publication or when sending notification of change of address, please supply the following information: name, company name, company address, type of business, and title of individual.

9. DU MONT WARRANTY

All instruments produced by the Instrument Division of Allen B. Du Mont Laboratories, Inc., are sold under the Du Mont Warranty. For the provisions of this warranty, see the Warranty and Service Notice on the inside back cover.

10. SERVICE

The Instrument Division maintains complete facilities for servicing Du Mont equipment. For details of the Instrument Service policies, see the Warranty Service Notice on the inside back cover.

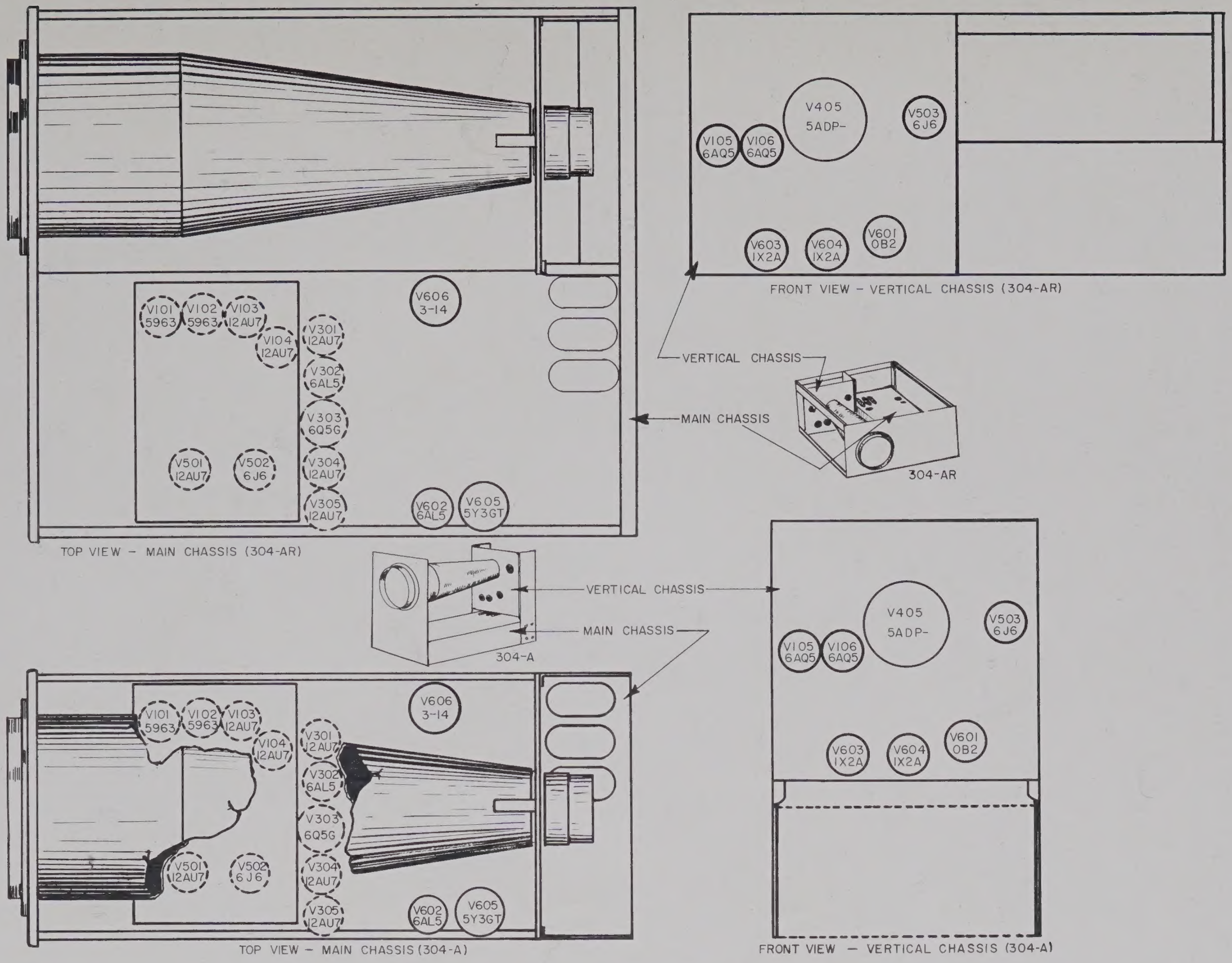


FIGURE 4-5. TUBE LOCATION DIAGRAM

WARRANTY AND SERVICE NOTICE

for

Industrial Type Cathode-ray Tubes and Instruments

DU MONT INSTRUMENTS

Each instrument manufactured by the Instrument Division of Allen B. Du Mont Laboratories, Inc., is guaranteed to equal or exceed its published performance specifications. It is further guaranteed against defective materials (other than the cathode-ray tube) and workmanship for a period of one year from date of delivery. Any defective instrument or an instrument that does not meet or exceed our specifications will, upon inspection by us, be repaired or replaced at our discretion should such defect appear within the guarantee period.

To register this guarantee, the enclosed guarantee card must be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information is necessary. BOTH THE TYPE NUMBER AND THE SERIAL NUMBER OF THE INSTRUMENT MUST BE GIVEN ON THIS CARD.

Instruments must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

DU MONT CATHODE-RAY TUBES

Industrial type cathode-ray tubes manufactured by Allen B. Du Mont Laboratories, Inc., are guaranteed for 1000 hours of operation or for a six-month period of installation, whichever shall first expire. The right is reserved, however, to limit claims to a period of nine months after shipment from the factory. Adjustments will be made on the merit of each individual claim because of the widely varying applications to which such tubes are subjected, and a tube which becomes defective during the guarantee period will be replaced ONLY AFTER INSPECTION AT THE FACTORY. Cathode-ray tubes which are sent in under the guarantee, must be sent with transportation paid.

BURNED OUT HEATERS AND BROKEN GLASS ARE NOT COVERED BY THE TUBE GUARANTEE

To register a tube guarantee, the guarantee card enclosed with the tube must be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information is necessary. TYPE NUMBER AND SERIAL NUMBER OF THE CATHODE-RAY TUBE MUST BE INCLUDED. The serial number of the tube will be found either on the glass stem of the electron-gun structure or on the bulb near the Du Mont brand. Tubes must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time and to furnish merchandise in accordance with current specifications without incurring any liability to modify equipment previously sold, or to supply new equipment in accordance with earlier specifications excepting under the classification of special apparatus.

SERVICE

In order to insure factory service under our guarantees, the guarantee cards enclosed with all instruments and tubes must be properly filled out and returned. In all cases where service or adjustment is requested, please write first to the factory giving complete information concerning the nature of the failure and describing the manner in which the equipment was used when failure occurred. THE TYPE NUMBER AND SERIAL NUMBER of the equipment must also be given. In this way, much time can be saved and unnecessary inconvenience often avoided. When writing in this respect, address:

Allen B. Du Mont Laboratories, Inc.
Instrument Service Department
1500 Main Avenue, Clifton, New Jersey

The Instrument Service Department will then send to the customer, the written procedure for sending the instrument back to the factory. All equipment should be packed and shipped in accordance with this procedure; and identification tags should be attached to each tube or instrument.

REPLACEMENT PARTS

If it is necessary to order a replacement component from the factory, always give the type number and serial number of the instrument and refer to the component by its symbol designation and description on the circuit schematic. This will help to expedite service.

DUMONT

Additional copies of this manual may be obtained at a cost of $1.50 each, post paid in U. S. only.

Allen B. Du Mont Laboratories, Inc.
Instrument Division
1500 MAIN AVENUE, CLIFTON, NEW JERSEY